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Knowledge Integration and Disruptive Innovation Product Development: Case Studies of Company A

Wen-Chun Tsai[1*], Yi-Han Su[2]
[12]Department of Business Administration
Chung Yuan Christian University
Phone: +0021952322756
[1*]Email: wctsai@cycu.edu.tw
Taoyuan City, Taiwan, R.O.C

ABSTRACT

Because of the energy crisis, companies started developing electric vehicles. Company A, as a new entrant, successfully developed a disruptive innovation of the world's first high-performance, zero emissions, and two-wheeled electric scooter. As disruptive innovation is frequently discovered in the combination of different industrial technologies, company A is comprised of high-tech and traditional industry resources and knowledge. This study aims to explore the process of heterogeneous industry knowledge integration in the traditional motorcycle manufacturing industry by a case study of company A. Following qualitative research method, this study concludes four main findings in product development: (1) organizational knowledge integration is identified to mitigate the impact of functional conflict; (2) design validation knowledge integration is identified to set the standard for pioneer product strategy; (3) internal and external engineering knowledge integration is identified to realizes the goal of pioneer product strategy; (4) product validation knowledge integration is identified to coordinate the flexible planning process.

Keywords: Knowledge Integration, Disruptive Innovation, Product Development

1. Introduction

Nowadays, climate change, energy shortage, and greenhouse effect issues enhance the public awareness of environmental protection and accelerate the industrial development of green energy. Attention has grown to the requirement to move toward innovation for more sustainable solutions and to reduce dependence on fossil fuels (Pinkse, Bohnsack, & Kolk, 2014). One of the industries that have come to the fore distinctly is the automotive industry, where is expected with the internal combustion engine (ICE), low-emission vehicles (LEVs) or electric, hybrid, and fuel-cell vehicles (FCVs) to be substituted for current fossil fuel consumption vehicles (Bakker, van Lente, & Engels, 2012) to solve severe air pollution, one of the main cause of global climate issues.

Scholars reveal that even with vast interest, because of existing manufacturers' centrality and dominant market shares, incumbents in the motorcycle industry consider an electric vehicle as a whole new and relatively competitive product, which seems to defend their current product positions and business models, hence forming a high barrier to move forward (Kemp, Schot, & Hoogma, 1998). The financial perspective is another factor that may be considered as the main role of influencing decision making. Markets in countries and industries are sophisticated, mature, and progressively commoditized; achieving market share growth is relatively expensive. For most firms, new product development implies production line extensions, technology improvements, and product innovations, and should also aim to maintain market share (Cooper, 2011). The literature has indicated the innovation process as a pricey and risky one, since organizations have to invest in research & development, training, and production operation, and the outcome is uncertain (Goedhuys,2007). Therefore, as the market size remains, companies increasingly compete for the market share by introducing insignificant but cost-saving new products one after another. In mature markets, the launch of a fully differentiated new product is rare these days (Cooper, 2011).

However, company A is recognized as a new entrant to the market and launched a disruptively innovative product of the world's first high-performance, zero emissions, and two-wheeled electric scooter in 2015. Company A also at the same time announced a battery swapping infrastructure that aims to promote and implement efficient, clean, and flexible energy use. Company A intends to become a technologically leading company transforming the system connecting sustainable energy and urban transportation. Unlike existing elder-aid electric scooters in the current market, company A provides their first series battery-swapping electric scooter with 95km/hr top speed, acceleration of 0 to 50 km/h in 4.2 seconds, and range of >100 km when traveling at speeds of 40 km/h which are considered as highly competitive to current mainstream fossil-fuel-powered scooters. Furthermore, it is marketed with its smart, high-quality, and high-tech features of smart-phone Bluetooth connection, programmable LED headlight, 30 onboard detecting sensors, customized sounds and light sequences of the headlights and taillights, aluminum liquid-cooled permanent magnet synchronous motor, and ultra-lightweight aluminum monocoque chassis.

With innovative technology, high performance, and unique design of scooter, company A's market share was more than 92% in Taipei and New Taipei City. According to

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company A's press release, in two and a half years, there are more than 50,000 electric scooters sold from company A, 150 million kilometers ridden by customers, 500 company A's battery swapping stations deployed across Taiwan, more than 25,000 battery swaps per day, 9 million total batteries swapped, and nearly 14 million kilograms less CO2 emitted. With record-high of sales by the end of 2017, Company A reached a 4.4% market share in Taiwan's domestic scooter market which secured company A's position as the nation's top electric scooter maker. Aside from breaking the company's record, this figure represents a record-high of electric scooter sales number in Taiwan as well.

Copious industries are influenced by technologically less sophisticated and market-driven innovations, but disruptive innovations are increasingly important both in high-tech industries and traditional industries (Assink, 2006; Christensen, 1997). Second, extant research focuses mainly on problems impeding and interfering incumbents from responding effectively to unpredictable disruptive changes (Markides, 2006). Little is known about the obstacles and opportunities new entrant firms encounter in developing disruptive innovation (Habtay, 2012). The purpose of this study is, therefore, to explore the process of heterogeneous industry knowledge integration in the traditional motorcycle manufacturing industry by a case study of company A and the methods of company A's knowledge integration realizing disruptive innovation.

2. Literature Review

2.1. Disruptive Innovation

Under the current dynamic business environment, which is outlined with rapid technological shift, product life cycle shortening, and globalization, innovations are considered as crucial to a firm's survival and growth (Chen, Tang, Jin, Xie, & Li, 2014). Accordingly, innovation has fostered significant interest among management practitioners and has become an important research topic. With reviews of the empirical literature, Yu and Hang (2010) indicated that Disruptive Innovation Theory, popularized by Christensen (1997), has been revealed as strategically crucial in practice. According to Christensen (1997), by different enterprise innovation scenarios, innovation can be divided into two innovation patterns: Sustaining Innovation and Disruptive Innovation. Disruptive innovators rearrange market combinations and create new value by identifying and creating new market segments or renovating existing markets.

Christensen and Raynor (2003) pointed out two different innovation entries, which are low-end disruption and new-market disruption. When exiting products or services is over-achieving consumers' requirements and expectations with relatively higher cost, low-end disruption might be identified to provide lower-pricing products or services by delivering a simple and clear message and functions that would fit customers' needs. Secondly, when current product characteristics can't attract potential customers, or consumer behavior is limited by inconvenience or insufficiency, new-market disruptive innovation could stimulate the market activeness.

Disruptive innovation has been emerged as a product or service significantly altered and improved in ways that the market did not expect by discovering new categories and segments of customers, or lowering costs, and enhancing the quality of consumer requirements in the existing market. Disruption does this partly by harnessing new technologies but also by developing new business models and exploiting old technologies in new ways. Moreover, Yu and Hang (2010) also reveal that new entrant firms have benefits and superior opportunities of success in disruptive innovations, which are differentiated from established companies, due to their smaller scale, shorter company histories, and relatively light commitments to value chains and current technological practices (Macher & Richman, 2004).

Disruptive innovation theory has cultivated a powerful influence on management practices and aroused plenty of rich debate within academia (Yu & Hang, 2010). Markides (2006) argued that different kinds of innovations entail different competitive effects and generate different kinds of markets, which should be considered as distinct phenomena. For example, business-model innovations and radical (new-to-the-world) product innovations were classified as disruptive technological innovations by Markides (2006). Firstly, Markides (2006) addressed that business-model innovation is discovered as a radically unique business model in an existing business. Two identical characteristics were indicated that (1) New customers (who are distinct from those existing competitors focus on) will be attracted by the new business models; And, (2) different from incumbents' current supply-chains, new and conflicting value-chains will be required by new business models in the industry (Pohl & Elmquist, 2010). Furthermore, disruptive business-model innovations aim to enlarge the current economic pie by bringing new customers into the market or by encouraging existing customers to join and accept the innovations (Markides, 2006).

The second type of innovation, radical innovation, approaches to be disruptive to the existing companies and competitors by introducing new-to-the-world products that none of the current products in the market can be considered as substitutes for. In addition, radical innovations are disruptive to customers and suppliers as well (Hill & Rothaermel, 2003). Prevailing consumers' behaviors and habits will be disturbed broadly as radical innovations are providing unexpected products and value propositions. And the markets that radical innovations create will reconstruct the combinations of core inquiring competencies and complementary assets that used to be those current competitors have built their success on. With observing on market behaviors, disruptive innovations are broken down into categories by Markides (2006) of business-model innovations and radical innovations, which pose fundamentally different challenges for established companies

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and implicate different connections and meanings for managers.

2.2 Knowledge Integration

At present, all industries are in a period of transition. The pace of technological innovation has shortened the life cycle of products and created new machines for the specific products responding to individual needs. Moreover, the ever-changing competitive landscape has blurred the industrial boundaries. Intangible knowledge assets, different from tangible assets and financial capital, have become indicating one company's competition capability's primary success factor within the knowledge-based economy (Kraaijenbrink, 2012). Especially for the project success of new product development, requiring the application of many types of specialized knowledge created and stored by individuals, the primary role of the firm is the integration of knowledge (Grant, 1996).

Within a company to realize knowledge integration, team members will present diverse portfolios of requisite abilities, skills, and know-how, and knowledge integration will be performed to actively absorb, incorporate, and combine different knowledge resources to achieve their goals. Therefore, interactively building on team members each other's ideas, skills, and expertise has become a key requirement for gaining new learning and knowledge integrating. This active assimilation and consolidation of individuals' specialized knowledge within firms are identified as internal knowledge integration (Mehta & Mehta, 2017). On the other hand, Assink (2006) argues that enhancing companies' absorptive capacity is considered as a crucial way to foster a firm's innovative capability, i.e. the ability for recognizing and understanding external knowledge, and then assimilate and apply it internally. Goedhuys (2007) indicates that innovation activities within companies also depend greatly on external resources to the firm. Proficient external collaboration can enhance a firm's knowledge byways of knowledge integrating with suppliers and other external knowledge sources. A firm's innovativeness can be increased by effective external knowledge integration (Pohl & Elmquist, 2010).

knowledge integration allows companies to identify and combine diverse knowledge elements that are spread around the organization and increase firms' ability to capitalize and internalize what they gain from different domains (De Luca, Verona & Vicari, 2010). In the new products development and firm performance, effective knowledge integration activities refine current technology, facilitate the exploitation of new skills and capabilities, and enrich the ability to seize opportunities (Grant, 1996). Furthermore, there are domain-specific knowledge, procedural knowledge, and general knowledge integrated through new product development processes affecting firm proficiency in capturing commercialization opportunities (Frishammar, Lichtenthaler & Rundquist, 2012). Therefore, knowledge integration will be considered a crucial activity in firms and is crucial to effective new product development.

3. Materials and Methods

To obtain insight information and details of the electric scooter project in Company A, a qualitative method, grounded theory, is applied in this study. Different from quantitative research, this study adopts the application of grounded theory for the following reasons: (1) In the characteristics of grounded theory, it contains the features of theory building (Corbin & Strauss, 1998); (2) Grounded theory is optimal for qualitative theory development and methods implementation when research is focused on exploring contextualization and process orientations (Charmaz, 2006); (3) Meanwhile, grounded theory has also been described as the most scientific methodology in qualitative research methods. It combines the advantages of methodology such as deep interviews, case studies, and field research. (4) From a data collection perspective, grounded theory is superior to questionnaire experimental design, and content analysis (Corbin & Strauss, 1998).

Regarding launching an innovation project, it brings attention to the composition of organizational participates. Company A, as a new entrant to the traditional scooter manufacturer industry, is combined with high-tech and traditional industry human resources to achieve the goal of disruptive innovation. Unlike existing traditional scooter makers, company A is found and led by a CEO who served as a former chief innovation officer of a phone maker company with extensive experience in mobile phone technology. He brought the high-tech industry's essence and technology into the traditional industry which hasn't been changed for years. Organizational members of Company A are also mixed with people from high-tech industries, like mobile phone companies, and from traditional industries, like automobile or motorcycle manufacturing companies, who should cooperate as the innovation project proceeds.

The sampling logic of grounded theory follows the principle of theoretical replication different from the generalization logic pursued by Statistics, and it focuses on the richness of sample information, further constructs and interprets a new theoretical framework. Theoretical sampling refers to sampling based on the concept that has been proved and formed to be relevant to the theory. According to theoretical sampling considerations, four qualified study subjects are identified in Table 1. They are core departmental managers participating in the electric scooter project from the very beginning, which are the organizational members in charge of launching the project. In addition, to be more comprehensive, they are respectively the heads of RD team and management team with background from the high-tech industry and traditional industry.

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Table 1: Interviewee List with Background and Transcript Number

Interviewee	Transcript Number	Position in Company A	Industrial Background	Interview Time
A	Trad_PM	Mechanical Program Manager	Traditional Industry	1:39:07
B	Trad_RD	Mechanical R&D Head	Traditional Industry	1:57:57
C	High-Tech _PM	Electrical Program Manager	High-Tech Industry	1:08:48
D	High-Tech _RD	Electrical R&D Head	High-Tech Industry	1:52:10

4. Case Analysis

4.1 Planning Stage

4.1.1 Innovation Initiation of Disruptive Product Development

I have to say that most of the time the priority was uniqueness over practicality. That's because it needs to be easy to recognize and striking on the road. (High-Tech_RD_2)

And for traditional scooter makers, maybe it's because they would rely on suppliers' technique and there was no one doing these kinds of functions before, so people will think they were difficult. (High-Tech_RD_3)

Despite the established standards in a traditional industry, company A choose its way to accomplish the goal of disruptive innovation and there is no previous example to be followed, therefore, company A can be viewed as **a "Pioneer Product Strategy"** to accomplish disruptive innovation.

We would spend a lot of time on product specifications in our previous company at this stage, and as well as a proposal for detailed design, test procedures, development schedule, and budget cost. However, in the current company, here, in the beginning, we only knew that we got a program but some product or module details were not identified yet. Instead, it proceeded oppositely that RD would feedback and define back to the specification set as designing was processed first before any detailed product specification was set. (High-Tech_PM_01)

Team members were used to having a standard planning process in previous working experience. However, a flexible product definition process was identified and proceeded in the opposite way of the traditional one. **"Flexible Planning Process"** appears when the traditional standard is not followed.

On the other hand, here, we got opportunities and time and we were asked for true differences from others. And most importantly, these unique ideas could be implemented. So, here, more innovation can be created and developed. (Trad_RD_4)

Since the boss was providing space for us to try new ideas, in this case, we would just go for it. Maybe we would encounter more failures than before, but if one of them succeeded, it could be one of innovation disruptiveness. (Trad_RD_3)

At the same time, company A further cultivates creative culture and environment for innovation initiation through providing innovation flexibility and space. Within an open environment, disruptive ideas and thoughts will not be blocked into standard patterns and more out-of-box thinking can be inspired with positive motivation during the innovation invitation stage. **"Creative Culture and Environment"** in company A is different from other standard processes that incumbents established.

4.1.2 Innovation Impacts of Disruptive Product Development

Previously scooter light controller was mostly designed in the light system, so you can see that scooter headlights are always big ones. However, for us, our product's external appearance was defined and confirmed at the very beginning. So, we got limited space for the lighting system and there is nearly no space for the controller. In the end, the EE team and our team figured out one solution that we separate and move the lighting controller out of lights and we can design and manage the controller by ourselves, just like disconnect-type. (Trad_RD_37)

In company A, regarding the innovation and difference, without limitation and gathering more space for developing innovation possibilities, an optimistic attitude was highly received from RD team members and created positive outcomes to accomplish disruptiveness. With an optimistic attitude around team members and new product design core direction, **"Innovation Stimulation"** was adapted gradually by members to absorb new principles and uniqueness-oriented strategy and output disruptiveness.

The company did not do it very well in the planning stage. The biggest difference and conflict is cost. As long as the cost section, in the original or previous industry, the

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product target cost will be settled firstly and followed with product specification development and planning. However, this company did not plan the project firmly. As the result, product design structure was added endlessly to pursue the perfect spec to accomplish the goal of innovation. In the end, the complete cost of the whole scooter was accumulated boundlessly. (Trad_PM_02)

To achieve the uniqueness of innovation, unrestricted space and open corporate strategy for organizational participants to explore ideas and experimentations with benefits of disruptiveness also come with the conflicts between standard operation concepts and process. For program management, dynamic and flexible budget and cost structure are out of function boundaries of management. **"Functional Conflict"** emerges with connections and observations of functional identified issues which were caused by the characteristic of innovation.

After the above 4.1.1 and 4.1.2 case analysis, at the Planning Stage, Company A initiated disruptive innovation product development through three important strategies, including **Pioneer Product Strategy**, **Flexible Planning Process**, **Creative Culture, and Environment**. The purpose of these strategies is to encourage new ideas and define a product that has a unique design in the market, as shown in Figure 1. For the organizational members, the innovation initiation also introduced some innovation impacts on their attitude and behaviors, including **Innovation Stimulation**, **Functional Conflict**. The RD functional teams were encouraged to think out-of-box ideas which are new to the traditional industry and provide resources for them to experiment. On the other hand, the PM functional teams found that it was difficult to manage the disruptive innovation product development program due to the uncertainty during the fuzzy-front end, as shown in Figure 1.

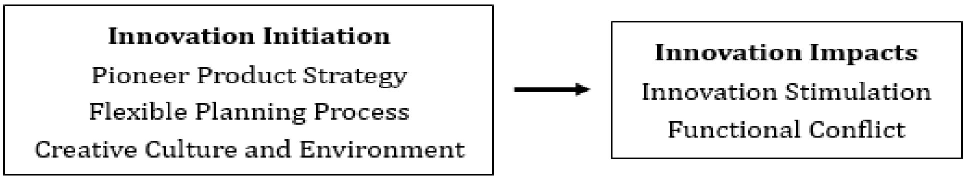

Figure 1: Innovation Initiation and Impacts of Disruptive Product Development

4.2 Design Validation and Engineering Stage

4.2.1 Organizational Knowledge Integration

Then I think it would be better to have a similar attitude to the mechanical side. That is to say, there are some accessories for this link that are connected to you or the function of the other parts. I think teams and teams still have to be a bit closer. Just come across the line to each other and honestly, we could avoid some unnecessary mistakes. (High-Tech_RD_19)

As the process goes to the design validation and engineering stage, most product development-related functions will be involved in this stage. **"Cross-Functional Cooperation"** brings enlarged space benefit for team members to explore disruptive possibilities and further to achieve innovation which might be freed from previous rigid functional responsibility definition.

At the present company, there was no DFM function. RD needed to design products and was also traveling between office and supplier sides for discussing engineering issues, modeling process problems, and modeling rationality. This approach was mainly because of the same practice as the 3C industry. It is reasonable for the 3C industry's practice because 3C engineers only had to bring one notebook to the factory to see how 3C products were produced which were related-small scales and sizes compared with traditional industry toolings. (Trad_PM_07)

In the end, this problem was not able to ignore and it caused a bad impact on the whole program operation, so after coordinating with functions, SQE would take over the job of DFM. (Trad_PM_08)

In company A, it was directly pointing out the differences of function role and responsibility between traditional industry and high-tech industry. Facing the differences, with the benefit of cross-functional cooperation, also leads industrial responsibility gap. **"Functional Role/Responsibility Specification"** helped to redefine the responsibility and work distribution to identify the most suitable cooperation between members.

After above 4.2.1 case analysis, facing the impacts of **Functional Conflict**, Company A recognized that the difference between heterogeneous industrial concepts caused the functional responsibility gap and distinction at the design validation and engineering stage. With the consistent goal of innovation development, the process of **Cross-Functional Cooperation** and **Functional Role/Responsibility Specification** would stimulate the knowledge interchanging between team members from different industrial backgrounds. Therefore, the disruptive innovation product development process requires organizational knowledge integration, as shown in Figure 2.

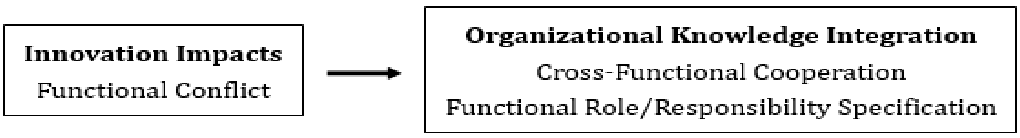

Figure 2: Organizational Knowledge Integration

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4.2.2 Design Validation Knowledge Integration

That's because PA (Product Assurance) all came from the high-tech industry. They thought the testing could be done in one month according to their experience in 3C product testing and they used to enlarge the number of testing units to reduce the testing time. But scooters sampling took more time to assemble and it cost a lot if you wanted to add on more sampling numbers. They are scooters, not cell phones. (Trad_RD_16)

So, after coordinating and communicating, the better solution for the two of us was that firstly testing would focus on RD's specification validation to make sure the product design was meeting the specification setting, and then PA could add on following strict testing to see the final product limitation degree. This was what we agreed upon after discussions. (Trad_PM_06)

It is highlighted to the industrial contrast in specification validation which would be the primary testing and product standard formulation at the design phase. Heterogeneous industrial knowledge was processing the period of interchange and cooperation and further derived the specific application process and approach to attain the stand of disruptive innovation. Therefore, in company A, two industrial representatives and team members figured out a combination and consensus of heterogeneous industrial specification validation procedure that joined the essence of two industrial aspects with the flexibility of trials for innovation possibilities. **"Specification Validation Standard Alignment"** for the industrial differences was realized after combining the importance of industrial perspectives and still kept the margin for the uncertainty of innovation exploratory.

After above 4.2.2 case analysis, at the design validation and engineering stage, under the setting of **Pioneer Product Strategy**, with identified the contrast between two industrial knowledge and further **Specification Validation Standard Alignment** reached for the applicable approach to realize the innovation purpose, knowledge integration, and interchange occurred during the process of difference identifying and reallocating the stance of the importance of actions and standards from a heterogeneous industry background, as shown in Figure 3.

Figure 3: Design Validation Knowledge Integration

4.2.3 Heterogeneous Industry Engineering Knowledge Integration

In the current electric scooter market, our product functions are unique and special that you cannot see them on other existing scooters. Most of these functions require us to combine and redesign existing solutions with our concepts. (High-Tech_RD_25)

If you design it traditionally, it would become a big scooter. So with really limited space now, every function strives for the space. So, we dropped the traditional steel pipe structure and tried on aluminum chassis with the die casting process. In this way, we choose a similar concept of cell phone layout that we can design and pile one function above another to utilize the maxima space. (Trad_RD_11)

Internally, innovation impact to the design validation stage primarily focused on industrial function advancement and heterogeneous industrial engineering design knowledge interchange from traditional and high-tech industry with one clear purpose of disruptive innovation achievement. The distinct heterogeneous industrial characteristics foster the technology and knowledge combination which are indicated by a significant degree of industrial knowledge complexity, and for RD disruptiveness in high-tech and traditional companies, knowledge integration becomes fundamental and a way to optimize the innovation establishment while knowledge tends to be a primary factor in enhancing competitive advantage. **"Cross-Disciplinary Exploration"** plays a significant role in the innovation fertilizing process.

As I mention, we didn't have a thorough plan at the planning stage. But with the purpose of mass production, the supplier would think that you would finish all the sampling and testing stages before handing over the design to the supplier for modeling toolings. But we speeded up our time and kept adjusting our tooling design or even reissuing the toolings. And suppliers were asked to follow with us which was uncommon for them. (Trad_RD_13)

It turns out that we would review the design with their outsourcing factory directly. Honest speaking, those suppliers might not understand all of the design details. We had to review with their outsourcing factory responsible engineers even though I think this is their duty to do that. If there were any problems with our product, it would still be our duty to resolve them. (High-Tech_RD_13)

To achieve innovativeness in product design and production process, requirements for the supply chain were no longer as same as the established industry. Innovation exceptional requirements were intensively demanded by engineers from cooperated suppliers. With the purpose of product specification implementation solidness, detail design review, and high-quality criteria into detail, not on the surface of systematic modules were strictly requested and those would be completely flipping supplier's cognition and experience operation principle. Moreover, to follow up with rapid design

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change which was caused by the innovation characteristic of uncertainty and spirit of possibility trials, instant response to changes was an exceptional requirement as well.

For responses from suppliers to the changes and additionally strict requirements caused by innovation, with company A case study, at first, suppliers presented negative responses with reasons of not being familiar with the cooperate difference and believing in the results that innovation would cause more effort during the process with fewer returns. Facing the negative attitude from suppliers at the first approach, team members presented active engagement with suppliers to share and interchange industrial knowledge and ideas for purpose of completing the innovativeness

Like our dashboard supplier. They mentioned that through the product development cooperation, their electrical engineers gained lots of new concepts on the design perspective and different attitudes toward the testing process. Of course, they had to pay a lot of effort into that, but at least when we asked or suggested to them to implement some solutions, they would try their best to meet our requirements. (High-Tech_RD_16)

Disruptive innovation would not impact the company only but also the entire industry and supply chain. When a new entrant presents the innovation to the traditional industry which also purposely disobeys the existing rules in the industry, it requires supply chain and new entrant's new form of cooperation on production and further leads to supplier chain transformation. As high-tech industrial knowledge is combined into the traditional scooter manufacturing industry, innovation fosters the industrial changes and further rebels the industrial standard which was implemented for years. Therefore, **"Cross-Organizational Collaboration"** was practiced deeply during company A's disruptive innovation design and production process to identify the most suitable cooperation between new entrants and traditions and also to ensure the feasibility of innovation.

After the above 4.2.3 case analysis, at the engineering stage, under the setting of **Pioneer Product Strategy** and **Flexible Planning Process**, innovation requires in-deep detail penetration and involvement due to the reason that deep to detail of the material is used or the functional definition was not as same as previous industrial practices and production process and methods might not be suitable to follow. As high-tech industrial knowledge is combined into the traditional scooter manufacturing industry, innovation fosters the industrial changes and further rebels the industrial standard which was implemented for years. Therefore, both **Cross-Disciplinary Exploration** and **Cross-Organizational Collaboration** were practiced deeply during company A's disruptive innovation design and production process to identify the most suitable cooperation between new entrants and traditions and also to ensure the feasibility of innovation, as shown in Figure 4.

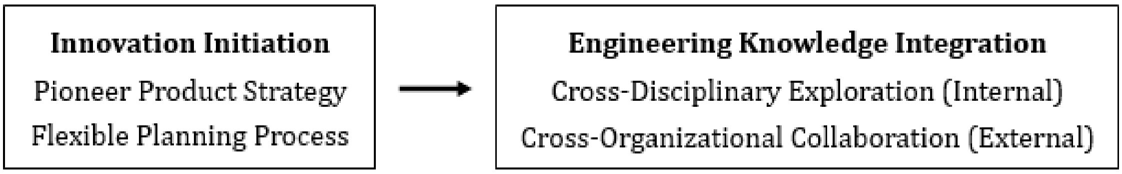

Figure 4: Engineering Knowledge Integration

4.3 Product and Production Process Validation Stage

4.3.1 Product Validation Knowledge Integration

It is the right logic and process for traditional industry, but this company is formed with high-tech industry culture and apply with 3C products' speed and tempo to produce products. Due to the rapid speed, mechanical R&D didn't have sufficient time to finish the product design testing. As same as electrical parts, we all have to be standby at the factory assembly line to make sure product assembly quality. (Trad_PM_14)

The cognition of the process and production stage is mainly focused on confirming that the factory's assembly maneuvering and SOP are correct, but for the high-tech industry, it is mainly focusing on verifying the quality of parts in the trial production stage. They think that it is reasonable that design issues occur at the trial assembly stage, so I think this is the biggest difference. (Trad_PM_13)

Product validation process dissimilarity was highlighted with primary conflicts on limited schedule arrangement and stage responsibility cognitive differences when the procedure requires two industrial participants' involvement which carried with previous industrial knowledge and working experience. When disruptive innovation was applied to product development, it was difficult to follow the standard production process which would fail to incorporate with innovating with flexibility and uncertainty.

Then, we just had to standby at the assembly line when the assembly factory started manufacturing with every assembly stop. If there were any problem occurred, we could analyze the issue, make the decision and find the solutions immediately. (Trad_PM_16)

The influence of R&D team members from the 3C industry is mainly focused on the validation stage. They had to spend more time and add up the quantity of sampling to testing R&D design and making sure the readiness for putting factory assembling line. (Trad_PM_18)

With encountering differences and dissimilarities, two groups of team members, therefore, responded with actions and further achieve product validation process collaboration. During the process of identifying the industrial dissimilarities between two industries and further fostering corresponding

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actions, **"Concurrent Development Coordination"** was conducted actively.

After above 4.3.1 case analysis, at the product and production process validation stage, under the setting of **Flexible Planning Process**, with identified the contrast between two industrial knowledge and further **Concurrent Development Coordination** reached for the applicable approach to realize the fast-paced development of disruptive innovation, knowledge integration and interchange occurred during the coordination between RD and PM group members to achieve quick responses to the product problems found in the production process, as shown in Figure 5.

Figure 5: Product Validation Knowledge Integration

5. Conclusion

Reviewing two innovation participants from industries with high heterogeneity interaction during the disruptive innovation product development shows heterogeneous industry knowledge integration actively processed during stages to accomplish disruptive innovation. Starting from the planning stage, the innovation project was considered as **Pioneer Product Strategy** and characterized by ideas initiated as relatively fragmentary, embryonic thoughts, and these raw ideas require a certain level of incubation with **Flexible Planning Process** to develop selected incunabular ideas into testable concepts in the first fuzzy front end phase. Additionally, **Creative Culture and Environment** was encouraged and had **Innovation Stimulation** influence on employees' creativity, innovation acceptance, and motivation over through the innovation impact generated within the company while innovation initiating. Furthermore, organizational knowledge integration occurs from the innovation impact of **Functional Conflict** which further facilitates **Cross-Functional Cooperation** and **Functional Role/Responsibility Specification** to respond to flexibility for innovation development.

Following the design validation and engineering stage, firstly, **Pioneer Product Strategy** played the main role of activating heterogeneous industrial RD cooperation to enhance and achieve product innovativeness where quality is considered as the primary performance criteria and further cultivates design validation knowledge integration on **Specification Validation Standard Alignment**. Secondly, **Pioneer Product Strategy** also positively fosters and requires engineering knowledge integration internally with **Cross-Disciplinary Exploration** and externally with **Cross-Organizational Collaboration**. Next to the product and production process validation stage, to validate the product and production process, it shows that as **Flexible Planning Process** set by firm directs the high standard outcome of innovation with a limited schedule which necessitates the incorporation of heterogeneous industrial knowledge for product validation, knowledge integration occurred during the process of identifying the dissimilarity and **Concurrent Development Coordination** forming between two groups.

Finally, there are four kinds of heterogeneous industry knowledge integration are identified in disruptive innovation product development, which is organizational knowledge integration, design validation knowledge integration, engineering knowledge integration, and product validation knowledge integration. It also reveals that the degree of knowledge integration is varied through the different stages of the product development process where the design validation and engineering stage reveals and requires the highest degree of knowledge integration both internally and externally.

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