A Delphi Study on the Collaboration Motive for Knowledge Fusion in Engineering[1]

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Abstract

This study aims to identify collaboration motive for knowledge fusion in Engineering. Delphi survey on a panel of experts was chosen to be the main methodology for this study, drawing the main factors of collaboration motive for knowledge fusion. From Oct. 10 to Nov. 25, 2013, a three-round Delphi survey was implemented to collect data. The panels of eighteen expert were involved in this survey. For statistical processing, descriptive statistics including frequency, percentage, mean and standard deviation were carried out along with internal reliability test on the survey instrument. The main findings were as follows. First, requirements for collaboration were found to be sufficient understanding and sharing of the collaboration goal, responsibility for the role, and intent to understand knowledge for collaboration. Second, knowledge management, as one of collaboration processes, included creativity applying previous knowledge, design for combined knowledge management system, and identification and arrangement of common elements. Third, the communication appeared as tolerance for different perspectives, consideration for collaboration, and patience to solve problems during collaborating. Fourth, decision-making as a result of collaboration showed share of vision and goal, rational decision-making using objective data, and mediating different opinions. Detailed information for collaboration for knowledge fusion found in this study would contribute to provide useful data for knowledge fusion studies.

Keyword: delphi study, collaboration motive, knowledge fusion, engineering, requirements for collaboration, knowledge management, communication process, decision-making

1. Introduction

Recently, knowledge fusion in engineering became popular, meaning many scholars realized that knowledge fusion between applied science and various social phenomenon would contribute to new ideas and innovation (Jeong, 2012; Korres & Tsami, 2010). However, engineering field has not explained how to realize knowledge fusion yet (Park, 2013; Leong & Clark, 2003; Teal, 2010).

Interdisciplinary studies between philosophy and engineering showed a possibility for connection and/or combination of different disciplines, which could not be connected in a traditional way. In addition, simple combination between two disciplines does not lead to worthy and creative issues for human beings (Oh et al., 2012; Gorman, 2010; Kotani, 2013; Sharon & Keiichi, 2009).

Knowledge fusion does not mean to convert someone's interest to one's own, but to provide an alternative in a process of reasonable negotiation (Oh et al., 2012; Gorman, 2010; Besselaar & Heimeriks, 2001; Frodeman, 2010; Sharon & Keiichi, 2009). Knowledge fusion is a process of solving complex problems, while two or more scholars who have different knowledge or belong to different discipline theorize and create methodology for new knowledge (Blics, 2000). It cannot be obtained by individual person's efforts, but requires interdisciplinary collaboration among different scholars. Whether the collaboration happens in a team, institution or discipline, dynamic interaction by collaboration and participation among various people results in creative problem-solving.

Previous studies in knowledge fusion explained that collaboration in a context of working participants who share vision and goal combines different perspectives, working as a living creature, and produces more than expectation. As a result, innovation like re-creation of knowledge can be accomplished.

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Collaboration as a base for knowledge fusion becomes important, but there are few studies to theoretically explain it. Thus, it is necessary to explore detailed information for collaboration and provide theoretical background for knowledge fusion.

Relevant studies suggest that collaboration consists of antecedents of realizing common goal, information sharing and communication based on mutual trust, and decision-making for accomplishing a common goal (Sanfort & Millward, 2006; Thomson & Perry, 2006). Also, collaborators work together to plan and implement, as well as to combine independent conceptual systems to make creative framework (Ancona& Coldwell, 1992; Isaksen& Lauer, 2002).

Considering previous study results, collaboration can become a base unit for knowledge fusion to connect and combine unique properties of different disciplines, pursuing knowledge fusion as a common goal. In addition, collaborative culture (such as knowledge management and communication) would contribute to an agreement among different discipline, resulting in discipline integration and creative products through a new way of problem-solving (Kock, 2008).

Collaboration has a possibility as crossroads among different discipline and a mediate variable for knowledge fusion. It would be possible to provide theoretical background for a feasible way for knowledge fusion, if function and role of collaboration become concrete. Thus, this study explores antecedents for collaboration, its process (knowledge management, communication) and outcomes (decision-making), using Delphi survey.

2. Theoretical Background

The term 'collaboration' has been used with partnership, coalition, joint-working, but it has been a main term in research field (Bryson, Crosby & Stone, 2006). This study defines collaboration as' a shared resources, responsibility and goal,' focusing on knowledge fusion in Engineering field. Specifically, collaboration means working interactively and producing certain results, that is, to exchange opinions, explore information, and make a decision together. In a process of combining, conflicting, and debating various perspectives, independent or incompatible concepts could put together and conclude an innovative way of problem-solving.

Collaboration might be beneficial to organizations and society, exchanging various resources and re-creating knowledge. It consists of three steps, antecedents, process and outcomes.

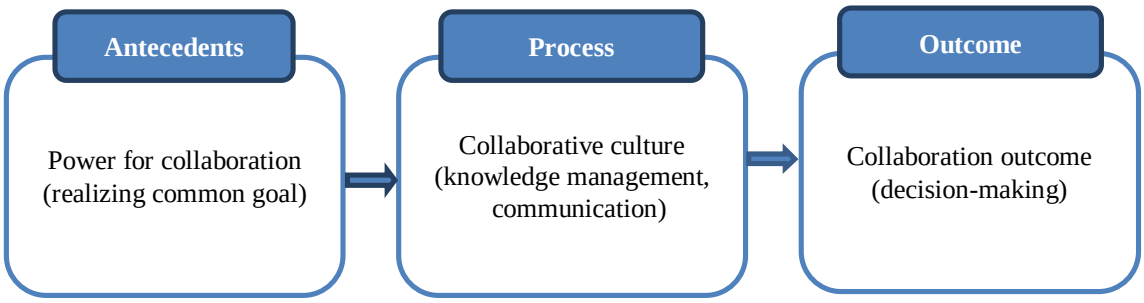

Figure 1: Collaboration Model

Collaboration is that professionals with different abilities and knowledge share and combine separate knowledge, and it is to draw an agreement on any given problems. Antecedents for collaboration include general agreement and cooperation. In addition, realizing a common goal becomes a power for collaboration, and now it is ready to begin collaboration (Kotani, 2013). Next, collaborative culture, such as knowledge management (sharing information) and communication based on mutual trust, is created. At this time, a formal way of reaching an agreement is necessary among participants. At last, outcomes include goal achievement and responsibility, meaning that a common goal is achieved through a rational decision-making process.

Literature review shows that a principle of collaborationis a reciprocity in professional skills. Collaboration can be a mediator for knowledge fusion, connecting and integrating various disciplines, hoping that it could solve difficult problems in the engineering field. As a base unit for knowledge fusion, the role and function of collaboration are defined as an important mediator. To explore constructs of collaboration, this study implements Delphi study with a panel of experts.

3. Methodology

3.1 Panel of Experts

A panel of experts for this study is selected to satisfy the following conditions.

First, experts have to own a doctoral degree in engineering, natural science, aesthetics, education, humanities and/or social science, at least having 5-year of teaching experience at university. Second, they should have previous experience in teaching fusion-related subjects or participating in relevant research. A total of 20 experts who agreed to participate in this study were selected, but only results from 18 experts who participated in three sequences of the study were analyzed finally (Table 1).

Table 1

Demographic variables	Item	N	%
Gender	Male	10	55.6
	Female	8	44.4
Age	30's	5	27.8
	40's	11	61.1
	50's	2	11.1
Level of Education	Doctoral candidate	4	22.2
	Doctoral Degree	14	77.8
Position	Professor	3	16.7
	Associate Professor	7	38.3
	Assistant Professor	5	27.8
	Instructor	3	16.7
Discipline	Engineering	6	33.4
	Natural Science	4	22.2
	Aesthetics	4	22.2
	Humanities/Social Science	4	22.2
Working Experience	5 to 10 years	9	50.0
	10 to 15 years	7	38.9
	More than 15 years	2	11.1
Total		18	100.0

3.2 Measurement

Delphi method was conducted three times from Oct. 10 to Nov. 25, 2013 (about one month and 15 days). The questionnaires for the first, second, and third round were developed jointly with three professors in education, including the main author of this study. After a pilot test was done with five experts and modified few items, the final questionnaires were distributed by emails and phone calls.

In the first round, open-end questions were distributed to collect various opinions, and a panel of experts described their opinions in each question marking an order of priority.

Questions included definition and requirements of collaboration, and variables of knowledge management, communication, and decision-making. (1. What do you think the most important antecedent for collaboration? 2. What do you think of knowledge management for collaboration? 3. What kind of communication do you think necessary for collaboration? 4. How do you think of decision-making for collaboration?)

Results from the first round were analyzed and re-arranged into the several items. The second round was conducted to evaluate the importance of each item (7-point Likert scale), which it results became a basis for developing the third round questionnaires.

3.3 Data Analysis

This study conducted descriptive statistics including frequency, percentage, mean and standard deviation and internal reliability for measurement. After the first round, the frequency of opinions placed in the first to third priority was analyzed, followed by a total frequency and a total of weighting.

Weighting was converted to Z value, and the first priority and the second priority were selected for the second round. In the second round, a panel of experts was asked to evaluate each item's importance. Mean, standard deviation and an average priority for each item were computed to place an order of priority. The importance was evaluated in 7-point Likert scale, 7 point for the most importance and 1 point for the least importance. To analyze consistency of experts' opinions, Kendall's W was conducted, judging if statistical significance is $p<0.5$, experts' opinions were statistically consistent. Results from the third round were analyzed, same as the second round.

4. Research Results and Discussion

4.1 Antecedents: the Requirements for Collaboration

The first round of Delphi study was done to find the definition of collaboration as a base unit for knowledge fusion and its required antecedents. Based on Z value of each question (±0.5 SD), 13 items were selected (M=7.75, SD=4.92). Results from the second round (Kendall's W=0.223, $p<0.1$) and the third round (Kendall's W=0.351, $p<0.01$) showed the consistency of experts' opinions. Specifically, the third round concluded 11 items as significant (Table 2). They suggested that shared goal, knowledge management, communication and decision-making were essential antecedents, whereas etiquette and mind-control for collaboration become very important.

Also, they were consistent to previous studies (including Blics (2000), Kotani (2013)), which insisted shared goal was a power and the beginning for collaboration. Thomson & Perry (2006)'s collaboration model was supported in this study, showing shared goal as an antecedent, knowledge management based on mutual trust and collaborative culture with communication as a process, and decision-making for achieving a shared goal as an outcome.

Table 2

	M	SD	Percentage			Avg. Priority
			25	50	75	
1. Potential to create a synergy effect	5.44	.984	4.75	6.00	6.00	5.72
2. Tolerance *for* other discipline's advantages	5.94	1.056	5.00	6.00	7.00	7.36
3. Decision-making	5.61	.698	5.00	5.50	6.00	5.92
4. Shared goal (sharing ideas)	5.89	.963	5.00	6.00	7.00	7.19
5. Intent to understand knowledge for collaboration	5.50	.985	5.00	5.50	6.00	5.56
6. Pursuit of goal consistency	5.39	.850	5.00	5.00	6.00	5.03
7. Maintenance to a horizontal relationship	4.11	1.367	4.00	4.00	5.00	2.17
8. Concern and communication for collaboration	6.11	.758	5.75	6.00	7.00	8.11
9. Understanding and sharing of collaboration goal	6.44	.616	6.00	6.50	7.00	9.53
10. Responsibility for the role	6.22	.732	6.00	6.00	7.00	8.47
11. Understanding in other's discipline	5.50	1.098	5.00	6.00	6.00	5.81
12. Deep understanding in one's own discipline	5.89	.963	5.00	6.00	7.00	7.14
N=18, Kendall's W=.351 Chi-Square=69.513 df=11, sig=.000						

4.2 Process of Collaboration: Knowledge Management

In the first round, 12 items for knowledge management as a process of collaboration were selected (M=7.17, SD=2.04). Results from the second (Kendall's W=.108, $p<.05$) and third round (Kendall's W=.153, $p<.01$) showed consistency in experts' opinions. These 12 items were finally selected based on results from the third round, telling a bit of difference in the order of priority in importance (Table 3).

These items emphasized a process of collecting, processing and analyzing ideas, knowledge and information produced in a process of collaboration. They were concurrent with Salas & Gelfand (2013), Sharon & Keiichi (2009).

Table 3

	M	SD	Percentage			Avg. Priority
			25	50	75	
1. building cataloging system for using knowledge	5.44	.856	5.00	5.00	6.00	6.22
2. exchanging and sharing of relevant knowledge	6.11	.963	6.00	6.00	7.00	8.36
3. documenting items appeared in a process of collaboration	5.50	1.043	5.00	5.50	6.00	6.22
4. arranging common elements in different disciplines	5.22	1.003	4.00	5.00	6.00	5.08
5. distributing outcomes from a process of collaboration	5.78	1.003	5.00	6.00	7.00	7.11
6. recording outcomes from a process of collaboration	5.50	1.249	4.00	6.00	6.25	6.58
7. building information system by keywords	5.50	.924	5.00	6.00	6.00	6.33
8. building a big data system for processable data	5.11	1.079	5.00	5.00	6.00	5.03
9. preparing a combined system for knowledge management	6.00	1.029	5.00	6.00	7.00	8.28
10. IT system for recording, saving and searching knowledge	5.28	.895	4.75	5.00	6.00	5.22
11. applying previous knowledge and showing creativity	6.11	.963	5.00	6.00	7.00	8.44
12. describing oneself as an expert	5.17	1.200	4.00	5.00	6.00	5.11

N=18, Kendall's W=.153 Chi-Square=30.390 df=11, sig=.001

4.3 Process of Collaboration: Communication

10 items were finally selected to consist of communication as a process of collaboration (M=8.80, SD=4.08). Based on results from the second (Kendall's W=.393, p<.01) and third round (Kendall's W=.385, p<.01), experts' opinions appeared consistent and 10 items were finalized as significant (Table 4).

In a process of collaboration, communication is found to make possible for participants to listen to each other, to accept other's opinions, to exchange opinions for problem-solving, and to make a decision. Also, this result supports the one from Thomson & Perry (2006), and Salas & Galfand (2013) which suggests that communication is a need to create or find a new thing.

Table 4

	M	SD	Percentage			Avg. Priority
			25	50	75	
1. free discussion(exchange of opinions)	6.17	.618	6.00	6.00	7.00	6.83
2. communication using IT techniques	4.28	1.018	4.00	4.00	5.00	1.75
3. exchange of information from different disciplines	5.83	1.098	5.00	6.00	7.00	6.08
4. explanation for one's own advantages/disadvantages	5.61	1.195	4.75	5.50	7.00	5.28
5. tolerance for other's discipline(accept differences)	6.33	.970	6.00	7.00	7.00	7.61
6. making new ideas by gathering and reviewing	5.94	.802	5.00	6.00	7.00	6.33
7. culture of a horizontal communication	5.44	.856	5.00	5.00	6.00	4.61
8. listening to other's opinions	6.00	.840	5.75	6.00	7.00	6.22
9. continuous efforts for change	5.17	.857	4.75	5.00	6.00	3.92
10. Patience to solve problems	6.00	.970	5.75	6.00	7.00	6.36

N=18, Kendall's W=.385 Chi-Square=62.336 df=9, sig=.000

4.4 Outcomes of Collaboration: Decision-Making

In the first round of Delphi study, 11 items were selected for explaining decision-making as outcomes of collaboration. Experts' opinions proved to be consistent due to results from the second (Kendall's W=.117, p<.05) and the third round (Kendall's W=.228, p<.01). After the third round, 11 items were found to be significant (Table 5).

These results emphasized a rational decision-making process through mediating and negotiating for achieving a shared goal. They also meant that though different opinions and perspectives might bring about conflicts, appropriate communication reduce negative effects of conflicts and produce creative ideas, which were similar to Lee &Rhi (2010) and Kock (2008).

Table 5

	M	SD	Percentage			Avg. Priority
			25	50	75	
1. decision-making based on objective information	6.39	.778	6.00	7.00	7.00	7.92
2. decision-making based on mutual interests	5.72	1.074	4.75	6.00	6.25	5.47
3. decision-making considering costs, effects etc.	5.72	1.018	5.00	6.00	7.00	5.47
4. maintaining an objective perspective	5.78	.878	5.00	6.00	6.25	5.75
5. sharing vision and goal	6.50	.786	6.00	7.00	7.00	8.36
6. transparency of decision-making process	6.28	.575	6.00	6.00	7.00	7.58
7. suggesting objective grounds	5.72	.895	5.00	6.00	6.25	5.58
8. Mediating different opinions through debates	5.83	.857	5.00	6.00	7.00	5.89
9. understanding advantages in simulation	5.22	1.396	4.00	5.50	6.25	4.28
10. judging a value of given information	5.33	.840	5.00	5.00	6.00	4.06
11. listening to minorities	5.67	1.138	4.75	6.00	7.00	5.64

N=18, Kendall's W=.228 Chi-Square=41.003 df=10, sig=.000

In conclusion, this study suggests following limitations and implications.

First, a panel of experts participated in this study confirmed collaboration as a base unit for knowledge fusion in the engineering field. The panel consisted of experts from engineering, natural science, aesthetics, humanities and social science. Though this study provided detailed information on collaboration, future study should include a wider variety of disciplines, such as business administration, medicine, and social science to check validity and reliability of collaboration.

Second, results of this study including antecedents, process and outcomes of collaboration, would be useful in studying knowledge fusion. A method used in this study depended on semi-structured questionnaires, and its limitation on accepting a variety of opinions would suggest a different method such as complete open-ended questionnaires for future study. Results from empirical research including this study would be used in interdisciplinary study and team efforts in various organizations.

Third, this study could provide indicators to evaluate the reliability of knowledge fusion areas. In addition, it could scientifically review capabilities of engineering students who completed knowledge fusion classes, and develop an instrument to measure collaboration.

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