A Delphi Study on the Convergence Program based on Rhizome Thinking and Expression in Engineering

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Abstract

Background/Objectives: This study aims to identify on the convergence program based on rhizome thinking and expression in engineering. Methods/Statistical Analysis: Delphi survey on a panel of experts was chosen to be the main methodology for this study, drawing the main factors of rhizome thinking and expression in engineering. From September 5 to September 30, 2015, a three-round delphi survey was implemented to collect data. The panels of twenty experts 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. Findings: The main findings were as follows. First, premise of rhizome thinking and expression were collaboration as a basic unit for convergence, convergence motive and convergence thinking. The collaboration appeared as a commitment of community projects, building cataloging system for using knowledge, exchanging and sharing of relevant knowledge, maintenance to a horizontal relationship, applying previous knowledge and showing creativity. Second, practice of rhizome thinking and expression was consilience as a lateral value, discovered in uniqueness and commonness of different disciplines. The consilience as a lateral value appeared as a communication using IT techniques, pursuit to unknown possibility in aesthetic, facing complete realities in engineering and science, a common thing between science and arts to an idea and creative thinking, convert ideas to actions in art and engineering. Third, method of rhizome thinking and expression was organic consolidation through a pattern of connection and communication. The organic consolidation appeared as a pursuit to apply a new form of technology, search for new and strange thing and plan for application using technologies, artificial intelligence, algorithm technology, conduct inference and verification repeatedly, analysis of human actions, design user interface, grasp similar products by market analysis. Application/Improvements: This study suggests the educational implications for improving convergence thinking and creative problem-solving for the engineering students.

Keywords: Convergence, Consilience, Consolidation, Delphi Study, Engineering, Rhizome

1. Introduction

The concept of convergence is defined differently in accordance with main disciplines. Convergence underlines finality as comprehensive understanding and creative problem-solving. Various types of disciplinary convergence works have been conducted, including types of convergence, methodology for convergence, convergence education, etc. As convergence is emphasized in a rapidly changing society, both consilience which gives a lateral value to all knowledge and the organic consolidation are required. It is because convergence is highlighted as an alternative to solve complex problems and its need and value are deeply discussed for drawing a more developed solution with various disciplinary knowledge.

Therefore, a new approach to disciplinary convergence in the engineering field should embrace 'consilience as a lateral value and the organic consolidation' by rhizome thinking and expression.

Here, rhizome thinking and expression indicates to identify similarities and differences among heterogeneous disciplines and to find an inter-connected point and a pattern for communication. To identify similarities and differences among heterogeneous disciplines becomes
possible through consilience as a lateral value. That is, by discovering that various levels which are previous thought as separate and unrelated are in fact complementarily connected, the range of our perception, experience, and action are widely expanded. And, the organic consolidation makes possible to find the interconnection and a pattern for communication. The unique problem-solving methods in each discipline are borrowed and converged in a complementary perspective.

However, to realize the possibility for consilience as a lateral value and the organic consolidation, the basic premise for various disciplines to interact with should be prepared. The disciplinary convergence is encouraged by collaboration in a multidisciplinary trading zone, convergence motive, and convergence thinking for trying the consolidation. In other words, the truth in a unique disciplinary system could be distributed into other disciplines by collaboration for creative problem solving. Based on the above findings, this study explores the concept of rhizome thinking and expression as a new approach to disciplinary convergence for creative problem-solving capability in engineering, using delphi survey.

2. Related Works

2.1 Collaboration as a Basic Unit for Convergence

Collaboration means to revise and integrate separate knowledge among people with different abilities and knowledge. It is to draw a general agreement on any given problems. The beginning of convergence emerges for realizing connection and logical integration by considering uniqueness of various disciplines and recognizing a common goal as knowledge fusion. Convergence motive indicates a personal dynamics to recognize and solve problems, thinking beyond the given boundaries of different disciplines. It means to recognize the original problems which would not be solved within the framework of the specific discipline, and it is equal to each individual’s intellectual curiosity, immersion, and interest in convergence in and out of the boundaries of disciplines. Convergence thinking is a new thinking system to integrate different disciplinary methods for solving problems, showing an important mediator for multidisciplinary convergence.

To be concluded, consilience as a lateral value and convergence as an organic consolidation creates convergence motive when experts from different disciplines collaborate with each other in a disciplinary trading zone, and later innovative and creative convergence thinking explodes and leads to creative problem-solving.

2.2 Consilience as a Lateral Value, Discovered in Uniueness and Commonness of Different Disciplines

Consilience as a lateral value explains a great process of integrating knowledge by dismantling disciplinary boundaries which are separated and departmentalized. That is, consilience as a lateral value is to understand other disciplines in a horizontal perspective for productive integration among various disciplines, moving beyond finding comparative advantages. This kind of perspective becomes possible by discovering uniqueness and commonness of various disciplines.

There are numerous studies to attempt convergence based on commonness among heterogeneous disciplines. According to them, creative expressions of arts, human understandings of humanities, and communication ability of social sciences belong to each discipline’s unique area as well as a common factor to increase the possibility of convergence among engineering fields.

In other words, an appropriate balance based on commonness and complementarity of different disciplines makes possible consilience as a lateral value.

To be concluded, consilience as a lateral value and convergence as an organic consolidation creates convergence motive when experts from different disciplines collaborate with each other in a disciplinary trading zone, and later innovative and creative convergence thinking explodes and leads to creative problem-solving.
logic and analysis from science, creative thinking and expression from arts, understanding of human nature from humanities, and understanding of human system from social sciences. They could be connected to uniqueness as well as commonness of various disciplines based on complementarity of similar disciplines.6,9,16,23–26.

2.3 Organic Consolidation through Pattern of Connection Communication

The organic consolidation in disciplinary convergence is a way to create a new life value by mixing various technologies and functions, unifying separated and fragmented technologies into a single system27,28. This provides an appropriate evidence for the convergence methodology, telling that each discipline has its own unique problem-solving methods. For example, engineering has the use of objective information, and science, arts, and humanities and social sciences have logical thinking, intuitive thinking, and subjective thinking, respectively. By connecting and integrating these unique problem-solving methods, cohesive thoughts and insights from more innovative groups would naturally appear at the intersection of various disciplines4,29,30.

Intuition has been used as a creative mediator in arts and humanities, traditionally, accepted as a catalyst for creating knowledge. However, intuition could create errors with subjective and one-sided biases, so logical thinking is necessary to fix this problem8.

Logical thinking has been traditionally used in a process of problem solving in math and science. And logical thinking is defined as a way of drawing a conclusion from the causal relationship of given information15,22,31–33. Premising all disciplines are science, logic is the algorithm itself to discover knowledge from the systematic thinking process and the foundation for the disciplinary convergence22. Meanwhile, the scientific problem-solving process requiring logical thinking tends to emphasize the positive contribution of intuition34. Thus, intuition has been accepted as a source for the real truth in a scientific problem-solving process.

Subjectivity explains the value of existence, with understanding in human beings as the prerequisite. It is defined as both the movement of mind which is aware of various phenomenon and things and one's own thought or one-sided thought33,35. Subjectivity focuses on the human being's inwardness or humans themselves. As a result, subjectivity becomes the important variable which should be considered for converging disciplines and finding the new truth.

Objectivity, opposite to subjectivity, is to look at or think about things in the objective term, leaving one's own thoughts33,35. This is a way of solving problems in engineering which deals primarily with facts and contents of thoughts as well as what knowledge talks about. Subjectivity as how to speak and objectivity as what to talk are the two extreme variables for explaining the target of disciplinary convergence as a subject and an object, and also they are considered as mediating variables33.

As Figure 2 indicates, the problem solving method of each discipline organically consolidates intuition and logic, subjectivity and objectivity and creates a pattern of communication, based on complementarity4. At this point, it creates a new knowledge and reach to a creative problem-solving in an easier way.

3. Methodology

3.1 Panel of Experts

As Table 1 indicates, 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 7-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 25 experts who agreed to participate in this study were selected, but only results from 21 experts who participated in three sequences of the study were analyzed finally.

3.2 Measurement

Delphi method was conducted three times from Jun. 1 to Jun. 27, 2015 (about one month). 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 consilience as a lateral value for convergence? 3. What do you think of organic consolidation?) 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.

Table 1. The demographic variables of Delphi panel

| Variables          | Item                  | N  | %    |
|--------------------|-----------------------|----|------|
| Gender             | Male                  | 11 | 52.38|
|                    | Female                | 10 | 47.61|
| Age                | 30's                  | 5  | 23.80|
|                    | 40's                  | 12 | 57.14|
|                    | 50's                  | 4  | 19.04|
| Level of Education | Doctoral candidate    | 3  | 14.28|
|                    | Doctoral Degree       | 18 | 85.71|
| Position           | Professor             | 5  | 23.80|
|                    | Associate Professor   | 6  | 28.57|
|                    | Assistant Professor   | 6  | 28.57|
|                    | Instructor            | 4  | 19.04|
| Discipline         | Engineering           | 6  | 28.57|
|                    | Natural Science       | 5  | 23.80|
|                    | Aesthetics            | 5  | 23.80|
|                    | Social Science        | 5  | 23.80|
| Working Experience | 7 to 10 years         | 9  | 42.85|
|                    | 10 to 15 years        | 8  | 38.09|
|                    | More than 15 years    | 4  | 19.04|
| Total              |                       | 21 | 100.0|

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 Collaboration as a basic unit for Convergence

As Table 2 indicates, 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), 11 items were selected (M = 10.27, SD = 6.00). Results from the second round (Kendall’s W = 0.280, p<0.01) and the third round (Kendall’s W = 0.385, p<0.01) showed the consistency of experts’ opinions. Specifically, the third round concluded 12 items as significant. These items emphasized commitment of community projects, building cataloging system for using knowledge, exchanging and sharing of relevant knowledge, maintenance to a horizontal relationship, applying previous knowledge and showing creativity, tolerance for other’s discipline (accept differences), shared goal and sharing ideas, Intent to understand knowledge for collaboration. Also, they were consistent to previous studies (including6,16), which insisted shared goal was a power and the beginning for collaboration. In19 creative problem-solving model and in17 collaboration model were 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.

4.2 Consilience as a Lateral Value, Discovered in Uniqueness and Commonness of Different Disciplines

As Table 3 indicates, in the first round of delphi study (M = 9.64, SD = 4.48), 12 items were selected for explaining consilience as a lateral value. Experts’ opinions (11 items) proved to be consistent due to results from the second (Kendall’s W = .156, p<.01) and the third round (Kendall’s
Table 2. Collaboration as a basic unit for convergence

| 1st Delphi results | 1rank | 2rank | 3rank | Sum | Score | Z-value |
|--------------------|-------|-------|-------|-----|-------|---------|
| 1. Shared goal and sharing ideas | 2     |       | 1     | 3   | 7     | -0.59   |
| 2. Intent to understand knowledge for collaboration |       | 4     |       | 4   | 8     | -0.43   |
| 3. Maintenance to a horizontal relationship | 1     | 2     | 3     | 6   | 10    | 0.06    |
| 4. Understanding and sharing of collaboration goal | 2     |       | 1     | 3   | 7     | 1.51    |
| 5. Responsibility for the role | 1     |       | 1     | 2   | 4     | -0.10   |
| 6. Commitment of community projects |       | 1     | 1     | 3   | 0.06  |
| 7. Building cataloging system for using knowledge | 4     | 3     | 2     | 9   | 20    | 0.22    |
| 8. Exchanging and sharing of relevant knowledge | 3     | 4     | 1     | 8   | 18    | -0.59   |
| 9. Applying previous knowledge and showing creativity | 2     | 1     | 2     | 5   | 10    | -0.10   |
| 10. Tolerance for other’s discipline (accept differences) | 1     | 1     | 2     | 4   | 7     | -0.10   |
| 11. Patience to solve problems | 4     | 3     | 1     | 8   | 19    | -0.59   |
| Total | 21    | 18    | 14    | 53  | 113   |

* Frequency Total = A simple sum of the rank frequency

Weighted score = Each item (1 ranking frequency × 3), (2 ranking frequency × 1), (3 ranking frequency × 1) the combined total score

| 2nd Delphi results | M | SD | Percentage | Avg. Priority |
|--------------------|---|----|------------|---------------|
|                   |   |    | 25 | 50 | 75 |              |
| 1. Commitment of community projects | 6.44 | .784 | 6.00 | 7.00 | 7.00 | 9.00 |
| 2. Building cataloging system for using knowledge | 6.39 | .778 | 6.00 | 7.00 | 7.00 | 8.75 |
| 3. Exchanging and sharing of relevant knowledge | 6.11 | 1.023 | 6.00 | 6.00 | 7.00 | 7.75 |
| 4. Maintenance to a horizontal relationship | 6.00 | 1.680 | 5.75 | 6.50 | 7.00 | 7.75 |
| 5. Tolerance for other’s discipline (accept differences) | 5.89 | 1.023 | 5.00 | 6.00 | 7.00 | 6.94 |
| 6. Applying previous knowledge and showing creativity | 5.72 | 1.776 | 5.00 | 6.00 | 7.00 | 7.08 |
| 7. Intent to understand knowledge for collaboration | 5.61 | 1.092 | 5.00 | 5.50 | 7.00 | 6.11 |
| 8. Shared goal and sharing ideas | 5.56 | 1.294 | 4.00 | 6.00 | 7.00 | 6.19 |
| 9. Issues raised | 5.56 | 1.199 | 4.00 | 6.00 | 7.00 | 6.08 |
| 10. Patience to solve problems | 5.28 | 1.364 | 4.00 | 5.50 | 6.25 | 4.94 |
| 11. Understanding and sharing of collaboration goal | 4.89 | 1.023 | 4.00 | 5.00 | 6.00 | 3.83 |
| 12. Responsibility for the role | 4.78 | 1.478 | 3.75 | 5.00 | 6.00 | 3.56 |

N=21, Kendall’s W=.280 Chi-Square=55.482 df=11, sig=.000
### 3rd Delphi results

| Priority | Percentage | SD 25 | M  | Avg. Priority |
|----------|------------|-------|----|---------------|
| 50       | 6.00       | 1.074 | 6.28 | 9.42          |
| 75       | 7.00       | 1.200 | 6.17 | 9.00          |
| 50       | 6.00       | 1.188 | 6.00 | 8.58          |
| 75       | 7.00       | 1.295 | 5.83 | 7.72          |
| 50       | 6.00       | 1.309 | 5.22 | 5.89          |
| 75       | 7.00       | 1.085 | 5.00 | 5.36          |
| 50       | 6.00       | 1.328 | 4.67 | 3.83          |
| 75       | 7.00       | 0.826 | 4.72 | 4.11          |
| 50       | 6.00       | 1.097 | 4.44 | 3.75          |

N=21, Kendall's W=.385 Chi-Square=72.291 df=11, sig=.000

### Table 3. Consilienc as a lateral value

| 1st Delphi results | 1 rank | 2 rank | 3 rank | Sum | Score | Z-value |
|---------------------|--------|--------|--------|-----|-------|---------|
| 1. Decision-making system in Science and engineering | 4      | 2      | 2      | 8   | 18    | -0.46   |
| 2. Communication using IT techniques             | 3      | 4      | 7      | 17  | 1.38  |
| 3. Understanding of purchasing mentality of humans in Social Science | 1      | 2      | 1      | 4   | 8     | 0.53    |
| 4. Pursuit to unknown possibility in Art and Aesthetic | 2      | 1      | 1      | 4   | 9     | -0.60   |
| 5. Idea generation techniques such as the expression of thought communication | 2      | 2      | 4      | 10  |       | -0.04   |
| 6. Facing complete realities in engineering and science | 1      | 3      | 2      | 6   | 11    | 2.94    |
| 7. A common thing between Science and Arts to an idea and creative thinking | 1      | 1      | 2      | 5   | -0.60 |
| 8. Convert ideas to actions in Art and engineering | 2      | 2      | 1      | 5   | 11    | 1.52    |
| 9. User satisfaction and need assessment in engineering and social science | 1      | 1      | 2      | 5   | -0.18 |
| 10. Understanding of human nature in Aesthetic       | 1      | 1      | 1      | 3   | 6     | -0.75   |
| 11. A common thing between Engineering and Science leads to a tendency to things | 2      | 2      | 6      | -0.60 |
| Total                                             | 20     | 19     | 8      | 47  | 106   |

* Frequency Total = A simple sum of the rank frequency
Weighted score = Each item (1 ranking frequency × 3), (2 ranking frequency × 1), (3 ranking frequency × 1) the combined total score
| 2nd Delphi results                      | M     | SD    | Percentage | Avg. Priority |
|----------------------------------------|-------|-------|------------|---------------|
| 1. Communication using IT techniques   | 6.33  | .767  | 6.00       | 7.00          | 7.81          |
| 2. Pursuit to unknown possibility in Art and Aesthetic | 6.22  | .943  | 5.75       | 6.50          | 7.00          | 7.64          |
| 3. Facing complete realities in engineering and science | 5.94  | 1.056 | 5.75  | 6.00  | 7.00  | 6.53          |
| 4. A common thing between Science and Arts to an idea and creative thinking | 5.89  | .963  | 5.00  | 6.00  | 7.00  | 6.44          |
| 5. Convert ideas to actions in Art and engineering | 5.89  | .900  | 5.75  | 6.00  | 6.25  | 6.58          |
| 6. User satisfaction and need assessment in social science | 5.72  | 1.179 | 4.75  | 6.00  | 7.00  | 6.06          |
| 7. Understanding of human nature in Aesthetic | 5.61  | 1.243 | 4.75  | 6.00  | 7.00  | 5.64          |
| 8. A common thing between Engineering and Science leads to a tendency to things | 5.50  | 1.043 | 4.75  | 6.00  | 6.00  | 5.19          |
| 9. Decision-making system in Science and engineering | 5.44  | 1.149 | 4.75  | 5.00  | 7.00  | 5.42          |
| 10. Idea generation techniques such as the expression of thought communication | 5.22  | 1.353 | 4.00  | 5.50  | 6.00  | 4.64          |
| 11. Understanding of purchasing mentality of humans in Social Science | 5.11  | 1.451 | 4.00  | 5.00  | 6.25  | 4.06          |

N = 21, Kendall’s W = .156 Chi-Square = 28.113 df = 11, sig = .002

| 3rd Delphi results                      | M     | SD    | Percentage | Avg. Priority |
|----------------------------------------|-------|-------|------------|---------------|
| 1. communication using IT techniques   | 6.50  | 1.295 | 7.00       | 7.00          | 9.06          |
| 2. Pursuit to unknown possibility in Art and Aesthetic | 6.22  | 1.166 | 6.00       | 7.00          | 8.19          |
| 3. Facing complete realities in engineering and science | 5.67  | 1.455 | 5.00       | 6.00          | 6.00          |
| 4. A common thing between Science and Arts to an idea and creative thinking | 5.89  | 1.183 | 5.75       | 6.00          | 7.08          |
| 5. Convert ideas to actions in Art and engineering | 5.89  | 1.183 | 5.00       | 6.00          | 7.00          | 7.06          |
| 6. User satisfaction and need assessment in social science | 5.22  | 1.309 | 4.75       | 5.00          | 6.25          | 4.75          |
| 7. Understanding of human nature in Aesthetic | 4.67  | 2.000 | 4.00       | 5.00          | 6.00          | 4.19          |
| 8. A common thing between Engineering and Science leads to a tendency to things | 5.22  | 1.166 | 4.75       | 5.00          | 6.00          | 5.33          |
| 9. Decision-making system in Science and engineering | 5.22  | 1.555 | 5.00       | 5.50          | 6.00          | 5.14          |
| 10. Idea generation techniques such as the expression of thought communication | 5.22  | .943  | 5.00       | 5.00          | 6.00          | 4.83          |
| 11. Understanding of purchasing mentality of humans in Social Science | 4.89  | 1.641 | 3.75       | 5.00          | 6.00          | 4.36          |

N=21, Kendall’s W=.295 Chi-Square=53.073 df=11, sig=.000

W = .295, p<.01). After the third round, 12 items were found to be significant. These results emphasized communication using IT techniques, pursuit to unknown possibility in art and aesthetic, facing complete realities in engineering and science, a common thing between science and arts to an idea and creative thinking, convert ideas to actions in art and engineering, user satisfaction and need assessment in social science, understanding of human nature in aesthetic, a common thing between engineering and science leads to a tendency to things, decision-making system in science and engineering, idea generation techniques such as the expression of thought communication.
Table 4. Organic consolidation through pattern of connection communication

| 1st Delphi results | 1 rank | 2 rank | 3 rank | Sum | Score | Z-value |
|--------------------|--------|--------|--------|-----|-------|---------|
| 1. Pursuit to apply a new form of technology | 2      |        |        | 2   | 6     | 2.27    |
| 2. Search for new and strange thing         | 3      | 1      | 1      | 5   | 12    | 0.21    |
| 3. Plan for application using technologies   | 4      | 1      | 1      | 6   | 15    | 0.73    |
| 4. Artificial intelligence                  | 2      | 1      |        | 3   | 8     | -0.43   |
| 5. Algorithm technology                     |        | 1      | 3      | 4   | 5     | -0.56   |
| 6. Conduct inference and verification repeatedly | 1    | 1      | 1      | 3   | 6     | 0.09    |
| 7. Understanding of human nature            | 1      | 2      |        | 3   | 7     | -0.30   |
| 8. Analysis of human actions (Cognition, emotion, action) | 2  | 3      | 2      | 5   | 8     | 2.53    |
| 9. Design user interface                    |        |        |        |     |       |         |
| 10. Grasp similar products by market analysis | 1    | 1      | 1      | 3   | 6     | -0.30   |
| 11. Information management system (Info exchange and share) | 2  | 1      | 2      | 5   | 10    | -0.43   |
| 12. Search planning theories                | 2      |        |        | 2   | 6     | -0.69   |
| Total                                        | 20     | 12     | 11     | 43  | 95    |         |

* Total Frequency = 1 rank frequency+ 2 rank frequency+3 rank frequency.
Weighted score = Each item (1 Frequency Rank× 3), (2 Frequency Rank × 1), (3 Rank Frequency × 1) the combined total score.

| 2nd Delphi results | M    | SD  | Percentage | Avg. Priority |
|--------------------|------|-----|------------|---------------|
|                    | 25   | 50  | 75         |               |
| 1. Pursuit to apply a new form of technology | 6.22 | .943 | 6.00 | 6.00 | 7.00 | 8.31 |
| 2. Search for new and strange thing         | 6.11 | 1.023 | 5.75 | 6.00 | 7.00 | 7.72 |
| 3. Plan for application using technologies   | 5.94 | 1.259 | 4.75 | 6.50 | 7.00 | 7.61 |
| 4. Artificial intelligence                  | 5.72 | 1.364 | 5.00 | 5.50 | 7.00 | 6.94 |
| 5. Algorithm technology                     | 5.72 | 1.320 | 4.75 | 6.00 | 7.00 | 7.14 |
| 6. Conduct inference and verification repeatedly | 5.67 | 1.237 | 5.00 | 6.00 | 6.25 | 6.33 |
| 7. Understanding of human nature            | 5.67 | 1.328 | 4.75 | 6.00 | 7.00 | 6.39 |
| 8. Analysis of human actions (Cognition, emotion, action) | 5.61 | 1.145 | 4.75 | 6.00 | 7.00 | 6.47 |
| 9. Design user interface                    | 5.44 | 1.338 | 4.75 | 6.00 | 6.25 | 5.92 |
| 10. Grasp similar products by market analysis | 5.28 | 1.965 | 4.00 | 6.00 | 7.00 | 6.31 |
| 11. Information management system (Info exchange and share) | 5.17 | 1.425 | 4.00 | 5.00 | 6.25 | 5.25 |
| 12. Simulation (Computer graphics)           | 4.22 | 1.927 | 3.00 | 4.00 | 6.00 | 3.61 |

* N=21, Kendall’s W=.142 Chi-Square=28.102 df=11, sig=.003

| 3rd Delphi results | M    | SD  | Percentage | Avg. Priority |
|--------------------|------|-----|------------|---------------|
|                    | 25   | 50  | 75         |               |
| 1. Pursuit to apply a new form of technology | 5.94 | 1.110 | 5.75 | 6.00 | 7.00 | 8.97 |
| 2. Search for new and strange thing         | 5.83 | 1.383 | 5.00 | 6.00 | 7.00 | 7.92 |
| 3. Plan for application using technologies   | 5.33 | 1.455 | 5.00 | 5.00 | 6.25 | 6.69 |
| 4. Artificial intelligence                  | 5.67 | 1.188 | 5.00 | 6.00 | 7.00 | 7.78 |
| 5. Algorithm technology                     | 5.56 | 1.097 | 5.00 | 5.50 | 6.25 | 7.06 |
| 6. Conduct inference and verification repeatedly | 5.50 | .985 | 5.00 | 5.50 | 6.00 | 7.22 |
| 7. Understanding of human nature            | 5.22 | 1.263 | 4.00 | 5.00 | 6.25 | 5.89 |
| 8. Analysis of human actions (Cognition, emotion, action) | 4.94 | 1.056 | 4.00 | 5.00 | 6.00 | 5.28 |
communication, understanding of purchasing mentality of humans in social science.  
Also, they were consistent to previous studies (including\textsuperscript{21}), which insisted possible by discovering uniqueness and commonness of various disciplines. In\textsuperscript{9,23}'s perspective were supported in this study, the consilience as a lateral value could be connected to uniqueness as well as commonness of various disciplines based on complementarity of similar disciplines.

### 4.3 Organic Consolidation through Pattern of Connection Communication

As Table 4 indicates, in the first round, 12 items organic consolidation as a process of knowledge fusion selected ($M = 7.92, SD = 3.00$). Results from the second (Kendall's $W = .142$, $p<.05$) and third round (Kendall's $W = .179$, $p<.01$) showed consistency in experts' opinions. These 12 items were finally selected based on results from the third round, pursuit to apply a new form of technology, search for new and strange thing and plan for application using technologies, artificial intelligence, algorithm technology, conduct inference and verification repeatedly, understanding of human nature, analysis of human actions (Cognition, emotion, action), design user interface, grasp similar products by market analysis, information management system (Info exchange and share), simulation (Computer graphics).

These items emphasized it creates a new knowledge and reach to a creative problem-solving in an easier way. They were concurrent with\textsuperscript{4,28}.

### 5. Conclusion

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 collaboration, consilience as a lateral value, discovered in uniqueness and commonness of different disciplines, organic consolidation through a pattern of connection and communication based on rhizome thinking and expression in engineering. This study 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. Therefore, results of this study can be constituted the basis for developing the convergence program based on rhizome thinking and expression in engineering. For example, the first step purports to understand the meaning of convergence as the premise of rhizome thinking and expression. The second step aims to understand the meaning of consilience as a lateral value, making possible in a trading zone of disciplinary convergence, as the first practice of rhizome thinking and expression. The third step, as the second practice of rhizome thinking and expression, aims to connect and integrate various disciplines' problem-solving methods at the intersection of disciplinary convergence.

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

### 6. Acknowledgment

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\begin{table*}[h]
\centering
\begin{tabular}{|l|c|c|c|c|c|c|}
\hline
\textbf{9. Design user interface}   & 4.72 & 1.406 & 4.00 & 5.00 & 6.00 & 4.53 \\
\textbf{10. Grasp similar products by market analysis} & 5.33 & 1.414 & 4.75 & 5.50 & 6.25 & 6.78 \\
\textbf{11. Information management system (Info exchange and share)} & 4.89 & 1.367 & 4.00 & 5.00 & 6.00 & 5.31 \\
\textbf{12. Simulation (Computer graphics)} & 4.67 & 1.328 & 4.00 & 5.00 & 5.25 & 4.58 \\
\hline
\text{N}=21, \text{Kendall’s } W=0.179, \text{Chi-Square}=35.368, \text{df}=11, \text{sig}=0.000
\end{tabular}
\end{table*}
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