

An Evaluation Method for Team Competencies to Enhance Nuclear Safety Culture

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Introduction

❖ Background

- **Safety culture was first introduced in 1986 after Chernobyl accident, and it received renewed attention recently in safety-critical industries including nuclear power plants (NPPs).**
 - Lack of safety culture is a major contributor to cause various prominent accidents, such as the Fukushima accident in 2011 and the concealment of a station blackout (SBO) of Kori NPP unit 1 in 2012.
- **Afterwards, a wide consensus grew among researchers that safety culture should be assessed and managed in a certain manner.**
- **There are three representative assessed methods :**
 - 1) Independent Safety Culture Self-Assessment (ISCA) developed by the IAEA ^[1]**
 - 2) Independent NRC Safety Culture Assessment developed by the United States Nuclear Regulatory Commission (US-NRC) ^[2]**
 - 3) Nuclear Safety Culture Assessment (NSCA) survey process developed by the Nuclear Energy Institute (NEI) ^[3]**

Introduction

❖ Background

❶ **However, the existing safety culture assessment methods have some limitations.**

- ❷ Evaluation of safety culture is made based on summing or averaging the results of interview and survey performed to individuals.
- ❸ Improvements suggested from the existing methods are at plant site level or organizational division level.
- ❹ Practices to improve individual or team safety culture are easily overlooked.



Therefore, it is necessary to develop safety culture evaluation method to provide explicit practices enhancing safety culture at individual and team level.

However, developing safety culture evaluation method at only team level by using Social Network Analysis (SNA) is considered in this work.

❖ Background

🔴 Why team?

- 🟡 Even the safety culture is maintained by the effort of the basic work units, teams, the existing methods of safety culture evaluation provide recommendations for a plant site or an organization.
- 🟡 Team safety culture has not been evaluated separately so far.

🔴 Why competency?

- 🟡 Competency is behaviourally seen, so that can be observable.
- 🟡 By adopting the concept of competency, it is possible to suggest that team members follow explicit practices and guidelines to improve team safety culture.

🔴 Why SNA?

- 🟡 The most significant feature of team safety culture is 'shared value' among team members.
- 🟡 SNA enables one to consider the organized structure of a team rather than simply summing or averaging the competencies of individuals.

❖ Objective

- ❶ To develop an evaluation method for team safety culture competency to enhance nuclear safety culture using SNA

❖ Scope

- ❶ To define and derive team safety culture competencies
- ❷ To develop the evaluation method for team safety culture competencies using SNA
- ❸ To develop the evaluation modules based on the developed method

Development of Evaluation Method for Team Safety Culture Competencies

❖ Definition of team safety culture competency

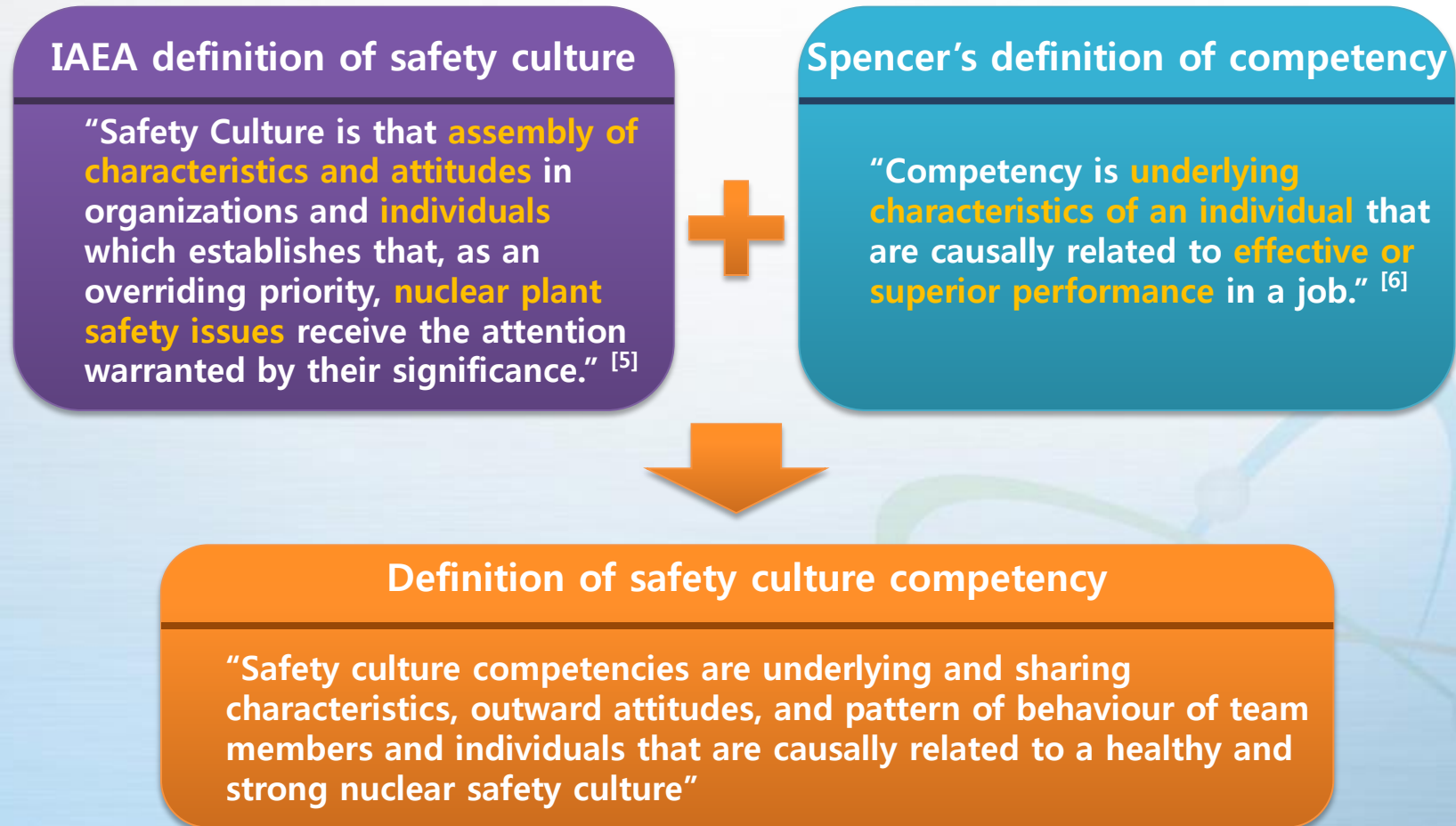


Fig 1. Definition of safety culture competencies

Development of Evaluation Method for Team Safety Culture Competencies

❖ Derivation of team safety culture competencies

- **In order to derive team safety culture competencies, strategic success modeling (SSM) was used among various competency-extracting techniques.**
- **Through SSM, competencies were extracted from high-performed subjects.**
- **Generally SSM follows the following steps.**
 - Step 1: Planning an effective and optimized derivation of competencies. In this step, the range and goal of competencies are also defined.
 - Step 2: Gathering information from behavioural characteristics of high-performed subject. In this step, the analyst scrutinizes behavioural characteristics to achieve target goal, through interview, workshop, or survey and so on.
 - Step 3: Defining the competencies based on the result of step 2. The list of competencies and their behavioural characteristics are derived.
 - Step 4: Validating the derived competencies. Validation is performed by statistical analysis and experts' judgment. Modification is also performed based on the result of validation.

Development of Evaluation Method for Team Safety Culture Competencies

❖ Derivation of team safety culture competencies

- We used task procedure rather than general interview, survey, or workshop, in order to gather information from behavioral characteristics of high-performed subjects. It is because the procedure itself suggests the behavioral standard to perform the task successfully.
- Total eight core competencies and their behavioral characteristics were derived.
- Additionally, reports and assessment criteria from various organizations were used to verify the competency list.



Fig 2. 8 Core competencies for team safety culture

Development of Evaluation Method for Team Safety Culture Competencies

❖ Derivation of team safety culture competencies

Table 1. Team safety culture competencies and their behavioral characteristics

Competency	Examples of behavioural characteristics
Leadership	<ul style="list-style-type: none"> Team members know their role and accountability clearly, and if it is insufficient, team leader alerts team members to know them. Team leader clearly understands the plant situation, and delivers the plant situation to team members. Team leader arbitrates the dispute when team members violate or implement procedures, regulations, and rules inappropriately. Team leader continually supervise whether team members are performing tasks within the standardized processes to perform safely. Team leader positively encourage team members to successfully perform tasks within plans.
Teamwork	<ul style="list-style-type: none"> Team members actively help and give advices to other team members. Team members consider the abilities of other team members in performing the given tasks. Team members avoid non-constructive arguments, and cooperate with other team members to perform the given tasks. Team members positively accommodate helps and advices from other team members.
Communication	<ul style="list-style-type: none"> Team members always have questioning attitude to the issues that might degrade safety of the plant, and express their opinions to other team members. Team members clearly deliver plant states to other team members when performing the given tasks. Team members discuss about corrective actions of an event, which degrades the safety or comes close to degrading the safety. Team members mutually confirm their understandings after discussion of major safety issues. Team members actively make a question for clear understanding of major safety issues. Team members share their experiences and information of major safety issues with other team members. Team members follow the communication protocol. Team members continually concern with the activities of other team members, and alert them when they perform wrong activities.
Task management	<ul style="list-style-type: none"> Team members cross-check the given tasks related to major safety concerns. Team members periodically inspect and manage the major safety components. Team members decide task priority considering safety. Team members manage their own tasks not to cause any inconvenience due to delay of performing tasks.

(Continued)

Development of Evaluation Method for Team Safety Culture Competencies

❖ Derivation of team safety culture competencies

Table 1. Team safety culture competencies and their behavioral characteristics

Competency	Examples of behavioural characteristics
Situation awareness sharing	<ul style="list-style-type: none"> • Team members share the situation that might cause degradation of safety. • Team members request information from other team members when the safety of plant state is unassured. • Team members share plans and information before performing the given tasks related to major safety issues. • Team members consider safety first, besides personal relationship between colleagues or team leader.
Motivation	<ul style="list-style-type: none"> • Team members pursue faultless decision-making. • Team members actively support other team members to raise teamwork.
Decision-making	<ul style="list-style-type: none"> • Team members gather and analyze the all accessible information to understand major safety issues. • Team members confirm additional opinions or suggestions before decision-making. • Team members endeavor to reduce uncertainty considering all the accessible information, such as time and methodology. • Team members confirm and verify the effectiveness of decision after decision-making. • Team members are periodically trained for emergency situations of the plant, and mitigate the situation based on the contents of trainings.
Emergency preparedness and response	<ul style="list-style-type: none"> • Team members are continually trained, reminding the precautions of unaccustomed tasks. • Team members share information to effectively manage the emergency situations and the abnormal situations. • Team members judge the risk level of unaccustomed tasks, and plan the tasks to mitigate the emergency situation appropriately. • Team members predict the latent hazards utilizing all the accessible information.



Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

● Definition of SNA :

- SNA is a strategy for investigating the relationship through the use of network and graphical element. [7]

● SNA characterizes the networked structures in terms of *nodes* and the *edges* that connect them.

● SNA has strengths that other methods do not have.

- Result from SNA shows the structure and relationship among team safety culture competencies.
- Result from SNA shows intuitive relationship through the network than any other methods.

● Generally SNA follows the following steps.

- Step 1: Gathering information to generate Event/Subject matrix
- Step 2: Visualizing the network graphically, based on the matrix
- Step 3: Calculating the meaningful values from the matrix

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

Table 2. An example of observation guideline (behavioral characteristics)

Team safety culture competency	Observation guideline (Behavioral Characteristics)
Teamwork	<ul style="list-style-type: none"> Team members actively help and give advices to other team members. Team members consider the abilities of other team members in performing the given tasks. Team members avoid non-constructive arguments, and cooperate with other team members to perform the given tasks. Team members positively accommodate helps and advices from other team members.

Team members	Team safety culture competencies				
		Leadership	Teamwork	Communication	...
	Team member1	4	2	1	...
	Team member2	0	2	3	...
	Team member3	0	1	0	...
	⋮	⋮	⋮	⋮	⋮

Fig 3. Number of inappropriate team safety culture competencies observed during the pre-determined time interval

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

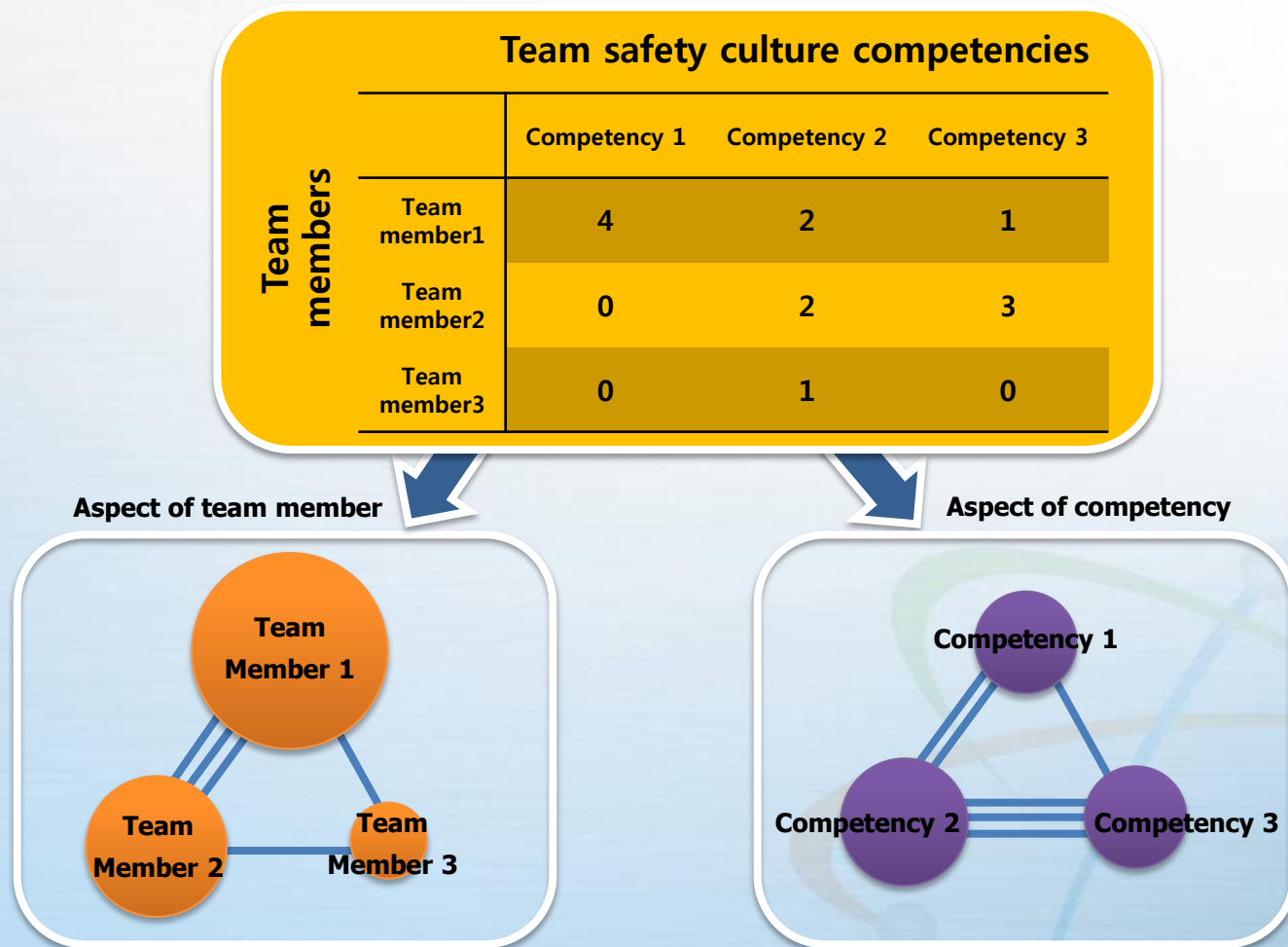


Fig 4. Graphical representations of SNA result according to the team and competency aspects

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

Team safety culture competencies		Competency 1	Competency 2	Competency 3
Team members				
	Team member1	4	2	1
	Team member2	0	2	3
	Team member3	0	1	0

Density of a team :

Degree that team members are observed as not having appropriate team safety culture competencies

$$D = \frac{L}{gC_2 \times i_m} = \frac{L}{\frac{g(g-1)}{2} \times i_m}$$

where, D: density of team members

L: number of lines

g: number of team members

i_m : maximum number of observations in competencies

Matrix Operation

Degree centrality of each team safety culture competency :

Degree that each team safety culture competency is not observed by team members

$$C_D(N_i) = \frac{\sum_{j=1}^g x_{ij}}{(g-1) \times i_m}, \quad i \neq j$$

where, $C_D(N_i)$: degree centrality of each competency

g: number of competencies

$\sum_{j=1}^g x_{ij}$: number of lines with other competencies

i_m : maximum number of observations in competencies

Fig 5. Numerical representations of SNA result according to the team and competency aspects

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

Team safety culture competencies

Team members		Competency 1	Competency 2	Competency 3
	Team member1	4	2	1
	Team member2	0	2	3
	Team member3	0	1	0

Fig 6. An example of observed data matrix

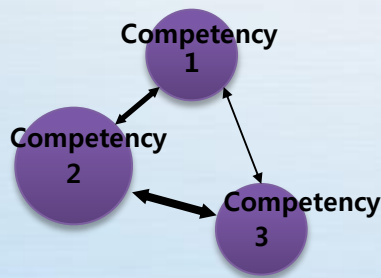


Fig 7. Graphical representation of the example

Density of a team: 0.416
(Team safety culture index: $1 - 0.416 = 0.584$)

Degree centrality of competency 1: 0.375
Degree centrality of competency 2: 0.625
Degree centrality of competency 3: 0.500

Fig 8. Numerical representation of the example



The results show that the team safety culture index is 0.584, and the most urgent team safety culture competency to be improved is competency 2.

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA

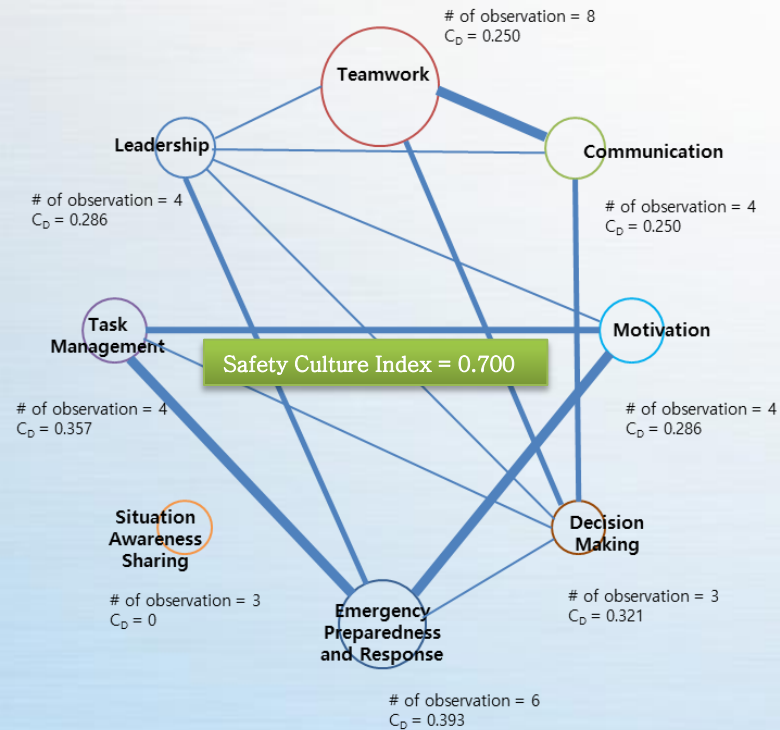
Table 3. An example of the observed data matrix

Team safety culture competencies

Team members		Teamwork	Communi- -cation	Motivation	Decision Making	Emergency Preparedness and Response	Situation Awareness Sharing	Task Management	Leadership
	Team member1	4	4	0	2	0	0	0	1
	Team member2	4	0	0	0	0	0	0	0
	Team member3	0	0	1	0	3	0	2	3
	Team member4	0	0	3	1	3	0	2	0
	Team member5	0	0	0	0	0	3	0	0

Development of Evaluation Method for Team Safety Culture Competencies

❖ Development of the evaluation method using SNA



Team safety culture competencies	C_D value (urgency)
Emergency preparedness and response	0.393
Task management	0.357
Decision making	0.321
Leadership	0.286
Motivation	0.286
Teamwork	0.250
Communication	0.250
Situation Awareness Sharing	0

● An example of the evaluation result of team safety culture competencies is shown in Figure 9.


● SNA of this example provides the following two important results.

- 1) Team safety culture index is 0.700
- 2) The most urgent team safety culture competency to be improved is 'Emergency preparedness and response'.

Fig 9. An example of the result of team safety culture competencies evaluation

Summary & Conclusion

❖ The evaluation method and modules for team safety culture competencies were developed.

- Team safety culture competencies were defined.
 - SSM was adopted to derive team safety culture competencies for a team.
 - SNA was applied to develop the evaluation method for team safety culture competencies analyzing 'shared value' among team members.
 - Both of mobile module for evaluation and PC module for review were developed.
 - The developed evaluation method of team safety culture competencies can provide explicit practices to enhance team safety culture.
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- [7] Scott, John. "Social network analysis." *Sociology* 22.1 (1988): 109-127

Thanks for your attention!

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