

Bridge Resource Management Training Programs in Korea and Their Effectiveness

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Objective: This study aims to introduce the bridge resource management (BRM) training courses implemented in Korea and to analyze their effectiveness in several views.

Background: BRM training will be a mandatory course for crew members of ships from 2017. At this stage, it is needed to check if the BRM training courses implemented until now was effective to the Korean maritime safety and to investigate if there are more effective training methods.

Method: The effectiveness of BRM training intervention in Korea was compared with that of the other countries, using Kirkpatrick's (1976) training evaluation framework. Kim (2012)'s data on the BRM training effectiveness were re-analyzed in order to check if the effects of BRM training are dependent on the bridge work experience.

Results: Many BRM training courses has been opened in Korea. However, the methods to assess BRM training effects used in Korea focused on the survey of subjective satisfaction level, not investigating trainees' attitude and behavior change. On the other hand, the effectiveness of BRM training was higher to the bridge officers with long work experience than with shorter work experience.

Conclusion: The contents of BRM training should be changed to effectively apply to the context of the real-world exercise and be differentiated depending on the work experience. Research on the methods to measure the BRM training effectiveness is also more required.

Application: The results of this study will aid to develop the BRM training courses for bridge officers of ships in the BRM training institutions.

Keywords: Bridge resource management, Human error, Maritime safety, Training effectiveness, Non-technical skills

1. Introduction

Crew Resource Management (CRM) was originated in the aviation industry to reduce human error over 20 years ago. CRM is a management system which makes the best use of all available means such as equipment, people and process in order to improve safety. Since 1980's CRM had been expanded and adopted for a number of other industries such as the nuclear, maritime and medical industry (Edkins, 2002). The maritime equivalent of CRM is termed Bridge Resource Management (BRM) and has been used in the maritime industry from the 1990s.

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BRM ability is enhanced by improving non-technical skills, which refers to a set of defined cognitive and social skills: communication, teamwork, situation awareness, leadership, decision making and workload management. Those skills contribute to enhance ability to work in teams and also enhance safety performance (Salas et al., 2001; Helmreich et al., 1999).

International Maritime Organization (IMO) recognized the need for non-technical skill training and described it in the STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers) as "competence in crisis management and human behavior skills for senior officers who responsibility of passengers in emergency situation" (IMO, 2010). Recently, IMO adjusted BRM training as a mandatory course for future seafarers through the revision of STCW in accordance with the 2010 Manila Amendments. A BRM training model course (Model Course 1.39) was suggested to provide a person with the knowledge, skill and understanding of leadership and teamwork at the operational level on board a ship (IMO, 2014).

On the other hand, Korean maritime industry has implemented BRM training in several maritime universities and private education institutions from 1999. Because BRM training will be established as a mandatory course from 2017 by IMO suggestion, it is expected that BRM training in Korea will be more expanded. At this stage, it is required to check if the BRM training courses implemented until now was effective to the Korean maritime safety and to investigate if there are more effective training methods.

This paper, at first, introduces BRM training courses in Korea, comparing with training courses in the other countries. Secondly, the effectiveness of BRM training intervention in Korea is compared with that of the other countries, using Kirkpatrick's (1979) training evaluation framework. Finally, Kim (2012)'s data on the BRM effectiveness are re-analyzed in order to check if the effects of BRM training are dependent on the bridge officers' work experience.

2. BRM Training Courses in Korea

BRM training in Korea is being implemented in five education institutions, including maritime universities and shipping companies. Although BRM training course until now was not a mandatory course for crew members on board at the operational level, many peoples participated in the training courses for the maritime safety. Table 1 shows training time and course intake limits in several training courses implemented in Korea (KIMFT, 2015).

Table 1. Examples of BRM training courses in Korea

Training institutes	Korea institute of maritime and fisheries technology	Korea maritime and ocean university	Hanjin ship management	Haeyoung maritime services
Training period	4 days	3 days	4 days	3 days
Training time	28 hours	18 hours	32 hours	24 hours
Number of students	12~20	5~40	4~30	5~40
Number of teachers	7	8	3~4	4
Training cost	505,000 Won	470,000 Won	480,000 Won	535,000 Won

BRM training in Korea started in 1999. About 750 maritime officers are taking the BRM course every year. It is expected that this number will be increased after 2017 in which BRM training becomes a mandatory course. About 5,000 people have to take BRM training courses, requiring at least 6 years to meet the educational requirements. Table 2 shows a record that four BRM training institutions educated every year from 1999 to 2011 (Kim, 2012).

Table 2. Examples of BRM training result per year in Korea

Training Institutes	Year										
	'99~02	'03	'04	'05	'06	'07	'08	'09	'10	'11	Total
Korea institute of maritime and fisheries technology	1,129	243	175	229	169	141	170	214	270	179	2,919
Korea maritime and ocean university	-	57	137	226	243	184	270	218	167	122	1,624
Haeyoung maritime services	-	-	-	-	99	131	165	204	216	164	979
Hanjin ship management	-	-	-	-	24	48	20	49	43	68	252
Total	1,129	300	312	455	535	504	625	685	696	533	5,774

On the other hand, the contents of BRM training course that was typically educated in Korea was compared with the training contents of model course 1.39 (IMO, 2014). The model course 1.39 represents a standard of BRM training contents. The detailed contents and teaching methods are not included in the model course 1.39. However, it is expected that the model course 1.39 can effectively guide the design of BRM training courses.

According to the result of comparison (Table 3), Korean BRM training contents does not cover several parts of main contents that the model course 1.39 guides. The uncovered contents include the informal social structure, workloads & fatigue, human limitations, resource allocation and situation awareness. A characteristic of uncovered training contents may be training topics closely related with the context of situation. The skills to cope with a variety of the context of situation are very important to prevent the maritime accidents. Training of pre-prescribed procedures and drills, independent of the context of situation, is not effective for the accident prevention. BRM training programs in Korea should be more changed toward the education of non-technical skills applicable to specific context of situations.

Table 3. Comparison of Korean BRM training contents with training contents of model course 1.39

Contents of model course 1.39	Contents included in Korean BRM training	Uncovered contents
Working knowledge of shipboard personnel management and training <ul style="list-style-type: none"> - Organization of crew - Cultural awareness - Informal social structure - Human error - Situation awareness - Team working 	<ul style="list-style-type: none"> - Human error - Cultural difference - Teamwork 	<ul style="list-style-type: none"> - Organization of crew - Informal social structure - Situation awareness
Knowledge of international maritime conventions, recommendation and national legislation <ul style="list-style-type: none"> - International maritime conventions - Recommendations and national legislation 	<ul style="list-style-type: none"> - This contents is covered in the other training courses* 	-

Table 3. Comparison of Korean BRM training contents with training contents of model course 1.39 (Continued)

Contents of model course 1.39	Contents included in Korean BRM training	Uncovered contents
Ability to apply task and workload management Planning and coordination - Human limitations - Workloads and fatigue - Challenges and response	-	- Human limitations - Workloads & fatigue - Challenges and response
Knowledge and ability to apply effective resource management - Communication - Allocation of resources - Assertiveness and leadership - Maintaining situation awareness	- Communication - Leadership	- Allocation of resources - Maintaining situation awareness
Knowledge and ability to apply decision making techniques - Situation assessment - Decision making - Emergencies	- Decision making - Reaction in emergency situation	- Situation assessment

※ Korean BRM training contents were cited from Thu et al. (2012).

3. Effectiveness of BRM Training

Training effectiveness should be precisely assessed to improve the training program and training method. The effectiveness of BRM training was not frequently measured. Table 4 presents two studies in Korea and six studies in the other counties that measured the effectiveness of BRM training.

The effectiveness of CRM training in aviation area was measured by the many researchers (Salas et al., 1999; O'Connor, 2011; O'Connor et al., 2002). Most of all studies reported that CRM training contributed to aviation safety. However, previous studies on the effectiveness of BRM training did not indicate significant positive effects. Röttger et al. (2015) reported that subjective satisfaction level and related knowledge were improved after training, but attitude and behavior of bridge officers was not changed.

Table 4. Previous studies on the effectiveness of BRM training courses

Country	Literatures	Results	Evaluation method/Statistical significance/Measures
Korea	Kim (2012)	Unclear results	- Questionnaires (satisfaction level), - Difference according to the work experience, - No inferential statistics
	Thu et al. (2012)	Unclear results	- Questionnaires (satisfaction level, Knowledge), - Difference according to the work experience, - No inferential statistics
Other countries	Fonne & Fredriksen (1995)	Unclear results	- Questionnaires (subjective stress level), - Pre-seminar VS after seminar, - No inferential statistics

Table 4. Previous studies on the effectiveness of BRM training courses (Continued)

Country	Literatures	Results	Evaluation method/Statistical significance/Measures
Other countries	Byrdorf (1998)	Unclear results	- Archival data analysis (safety and damage records) - No inferential statistics
	Brun et al. (2005)	Unclear results	- Observation and Questionnaires (shared mental Model, several performances), - Comparison between teams with and without BRM training - No inferential statistics
	O'Connor (2011)	No significant difference	- Questionnaires (knowledge, attitudes) - Comparison between teams with and without BRM training
	Röttger et al. (2015)	Partially significant difference	- Observation and Questionnaires (reactions, knowledge, attitudes, behavior performance) - Comparison between teams with and without BRM training, - Difference in reaction and knowledge, - No difference in attitudes, behavior and performance

On the other hand, BRM training ultimately should give positive effects on the organization that the trained people are affiliated. An evaluation framework to measure this effect was suggested by Kirkpatrick's (1979). His evaluation hierarchy provides a useful framework to assess the effects of training intervention on an organization as shown in Table 5. The hierarchy consists of four levels of evaluation: reactions, Learning, behavior and organization.

Table 5. Kirkpatrick's (1979) evaluation hierarchy composed of four different levels of evaluations

Levels	Explanations
Level 1: Reactions	Reactions are related with how the participants react to the training. Evaluating reactions is to measure customer satisfaction.
Level 2: Learning	Learning stands for the principles, facts, and skills which were understanding and absorbed by participants. It is measured acquired knowledge and modified participants' attitude or beliefs.
Level 3: Behaviors	Behavior level is assessed by measuring whether knowledge learned in training is transferred to behaviors on the job.
Level 4: Organization	Organizational level is the ultimate aim of any training program, such as an improvement in safety and productivity.

BRM training effectiveness was primarily focused on the level 1 (reaction) and level 2 (learning) in the views of Kirkpatrick's (1979) evaluation hierarchy. In particular, BRM training effectiveness in Korea was evaluated by the only questionnaires, measuring subjective satisfaction level and acquired knowledge. The ultimate aim of the BRM training is to change bridge officers' attitudes and behaviors and to improve safety in the organization. The methods to efficiently measure BRM training effectiveness should be developed and should be actively applied in Korean maritime industry.

4. Re-analysis of Kim's (2012) Data

Kim (2012) surveyed 300 Korean bridge officers who had participated in BRM training courses. Participants were divided into three groups according to the time of work experience on board; below 3 years, 3~10 years and over 11 years. The effectiveness of BRM training was measured in three perspectives; course's satisfaction level, course contents' conformity to practical ship tasks and course's contribution to safety operation. Four point rating scale ranging one (very low) to four (very high) was used for the subjective rating. No inferential statistics was not given in Kim (2012); providing only descriptive statistics. Re-analysis was required to manifestly show the effect of work experience.

Figure 1 shows subjective rating on the satisfaction level according to the work experience. Overall effectiveness of BRM training was not low; over 68% (2.7) in three measures (73% (2.9) for the satisfaction level, 68% (2.7) for the conformity to practical tasks and 70% (2.8) for the contribution to the ship operation). The one-way ANOVA was conducted on the each three measure. The satisfaction level was significantly different according to the time of work experience ($F(2, 297)=11.15$ $p<0.001$). The result of Turkey test was grouped into two groups; (Above 11 years) > (below 3 years, 3~10 years).

The course contents' conformity to practical ship tasks was not significantly different according to the time of work experience ($F(2, 297)=1.10$ $p=0.333$). The course's contribution to safety operation was significantly different according to work experience ($F(2, 297)=3.10$ $p<0.046$). However, the result of Turkey test was not significant, indicating impossible grouping.



Figure 1. Subjective rating on satisfaction level, conformity to practical work and contribution to the ship operation according to the work experience

5. Discussion and Conclusions

Many researchers insist that human error is a main cause of maritime accident and human error should be reduced for the maritime safety. The majority of human error is not caused by technical problems but by the failure of the crew to respond appropriately to the situation. Therefore, developing non-technical skills and the optimal use of crew resources is an important means to prevent human errors and accidents in maritime world.

Although BRM training is introduced in the maritime world for those purposes, the effectiveness of BRM training is low according to the results of previous studies. Röttger et al. (2015) tried to search for the cause of the low effectiveness from the fact that BRM training focused on the general knowledge, skills and attitudes. Barnett et al. (2006) also insisted that BRM training in maritime area is still relatively immature in comparison with the non-technical skills training and their assessment in aviation industry.

The trend to just educate general knowledge, skills and attitudes also occurred in Korean maritime industry. Many BRM training courses were opened for the crew members of ship, but the contents and training method of the training courses was not enough to heighten the effectiveness of the training. Training contents should be added training topics closely related to the context of situation such as informal social structure, workloads & fatigue, resource allocation and situation awareness. Methods to evaluate the training effectiveness should be also developed and the effectiveness should be frequently evaluated after training.

Until now, Korean maritime industry used to survey by the questionnaires, measuring subjective satisfaction level and acquired knowledge, to measure BRM training effectiveness. It is required to evaluate the changes of bridge officers' attitudes and behaviors. CMAQ (Cockpit Management Attitude Questionnaire) was suggested for assessing CRM-related attitude of aviation pilots (Helmreich, 1984; Gregorich et al., 1990). After that, SMAQ-GN (Ship Management Attitude Questionnaire-German Navy) was suggested as a maritime version of CMAQ (Röttger et al., 2013). Such a method would be effective to measure the changes of bridge officers' attitudes.

On the other hand, the changes of bridge officers' behaviors should be effectively measured. To assess behaviors, aviation industry used a behavioral marker system called Targeted Acceptable Responses to Generated Events or Tasks (TARGETs). Behavioral markers are "a prescribed set of behaviors indicative of some aspect of performance" (Flin and Martin, 2001). The TARGETs system was based upon the seven critical aircrew behaviors that are taught in the CRM training (Fowlkes et al., 1994). NOTECHS (NON-TECHNICAL Skills observation and rating system) was also developed as a tool to observe and rating the behavior of pilots (van Averaete and Kruijssen, 1998; O'Connor et al., 2002). These tools should be adapted in the Korean maritime industry.

Finally, the effect of BRM training occurred higher on the maritime officers with the long work experience than the short work experience. Maritime officers with long career may consider that they have to manage bridge resources. Maritime officers with long career may consider that they have to manage bridge resources. Maritime officers with short career may consider that they should focus on the learning of technical skills such as a procedure to use the maritime equipment. The difference of this thought may be reflected on the effectiveness of BRM training. However, all bridge officers should actively participate in the BRM to improve maritime safety. The contents of BRM training may be differentiated according to the work experience on board.

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