A Study on the Perception of Vessel Collision Risk of Trainees

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ABSTRACT

According to the recent statistics of maritime accidents in Korea, collisions were the most common accidents related to maritime traffic. In IMO Model Course 7.03, which stipulated the training course to become an officer in charge of navigational watch, education on COLREGs72 takes up the most time. However, collision prevention education is insufficient in the training curriculum of Korea maritime educational institutions. Therefore, this study aims to suggest the need of collision prevention education for trainees by presenting the current status of Korea's on-board training and the trainees' perception of collision risk. To examine the trainees' perception of collision risk, a survey was executed on the trainees in training ships of the Korea Maritime and Ocean University at the 2nd semester of 2021. The valid responses of the survey were compared with the PARK (Potential Assessment Risk) Model, which is maritime traffic risk models of Korea. Analysis shows that as the boarding period has elapsed, the trainees felt a higher risk in encounters with other ships, and perception of collision risk among the trainees became similar. When comparing trainees and the PARK model, it was found that consigned trainees of 1st semester were most similar to the collision risk perception tendency of PARK model when they disembarked. This seems to be because, the consigned trainees spent a lot of time on the navigational watch on merchant ships during the 1st semester. However, the capacity of consignment training is restricted, so that the necessity for collision prevention education was magnified. Therefore, an AHP-based survey was conducted in order to derive the optimal collision prevention education method. As a result of the analysis, it was verified that simulation training is suitable for a collision prevention education. This study can be used as fundamental research for the development of collision prevention education using the simulator.

1. Introduction

According to the statistics of maritime accidents in Korea, 1,275 cases of collision have occurred the most in traffic-related accidents over the past five years (KMST, 2022). In addition, collisions are the most common in investigation of accidents among marine accidents. Therefore, collisions at sea are the greatest risk to ship operation in Korea. In IMO Model course 7.03, which contains the training course for the officers in charge of the navigational watch, the largest amount of training hours was allocated to the training on the collision regulations (IMO, 2014). Through this, it can be said that in order to become a ship operator, it is necessary to have thorough knowledge of collisions. Therefore, the on-board training course of Korea maritime educational institutions was checked in order to confirm whether they are providing collision prevention education sufficiently. As a result of the verification, the training on collisions in the training ship was insufficient. However, it was revealed that in the on-board training, trainees were learning and experiencing collision regulations naturally according to the knowledge of faculty members. Though, since trainees are put into the field immediately after graduation and work as actual ship operators, it seems necessary to introduce a systematic collision prevention education. Therefore, this study aims to raise the need of introducing collision prevention education in the training course of the training ship by identifying the current status of training in training ship and verifying the trainees' perception of collision risk.

Among the previous studies related to the on-board training, Lee et al. (2019) extracts appropriate elements for effective simulation-based training of trainees and presented guidelines for the training plan. There is also a study that suggested the educational direction of on-board training for each semester by analyzing the difference in understanding of navigational ability according to the boarding semester (Kim et al., 2020). Meanwhile, Park et al. (2018) analyzed specifically improved ability of trainees in addition to the effect on the duration of on-board training. On the other hand, Im and Sin (2018) conducted a survey and personal interview with students who experienced on-board training, and requested the improvement of the boarding training process so that it can be fit to the reality rather than focusing only on the record. Kim et al. (2018) investigated the actual conditions of consignment training by ship type, size, and age, focusing on the work and rest of commissioned trainees. Moreover, Kim et al. (2018) conducted a study to identify the working conditions of consigned trainees based on the survey and to suggest improvement in their treatment.

Thus, the previous research on trainees focused on verifying the educational effect according to the training period, identifying navigational skills through questionnaires, demanding improvement of the curriculum, and urging for improvement of the training environment through the survey. However, in this study, as a basic study for introducing collision prevention education into the on-board training course, the collision risk was analyzed from the trainee's point of view and compared with ship operators.

2. Status of on-board training in Korea

In Korea, Korea Maritime and Ocean University (KMOU), Mokpo National Maritime University (MMU) and National Maritime High School (MHS, including Korea Maritime and Fisheries Training Institute, KIMFT) are conducting on-board training courses to become ship operators through their own training ships. Among them, KMOU was established in 1919 and after being promoted to a university in 1946(KMOU, 2022). It has developed into Korea's representative maritime training institution for over 70 years. Accordingly, KMOU was selected as a representative institution for understanding the current status of on-board training in Korea.

2.1 On-board training in KMOU

In accordance with Article 58 (1) of the statutes of KMOU, students at the college of Maritime Sciences are required to conduct on-board training on the training ship or other vessels designated by the president (KMOU, 2022). Therefore, juniors at the college of Maritime Sciences will participate in campus training using a training ship and consignment training consigned to a merchant ship of a shipping company per semester.

Before on-board training, students at the college of Maritime Sciences apply to the shipping company or training ship of their choice. Students who complete the consignment training are more likely to be employed as officers of merchant ships after graduation, so many students apply for the consignment training. Thus, the number of students who want consignment training usually exceeds the number of students requested by shipping companies. Therefore, the relevant department calculates the credits and language proficiency of those wishing a consignment training and assigns them, starting with the highest score.

2.2 Status of campus training in KMOU

Juniors who wished for consignment training but did not attend, and those who wished campus training attend campus training on the training ship owned by the school. As a result of checking the ship’s particular of the KMOU training ships, it was found that the HANBADA and HANNARA can accommodate 410 trainees in the campus training in a semester. However, from 2020, due to the government's quarantine guidelines for COVID-19, the capacity has been modified that the number of trainees does not exceed 50% of capacity, so that only 205 trainees can embark in a semester. Accordingly, in order to satisfy the standard of boarding days of more than 205 trainees, trainees who were scheduled to board the training ship were divided into 1st and 2nd phases. Therefore, out of 6 months, the trainees boarded the training ship for 3 months and participated in remote classes at home for the remaining 3 months. In consequence, it was confirmed that the trainees who participated in the campus training in 2021 boarded for the number of days shown in the table below.

Table 1 Boarding period of campus training in 2021

Time		Embarkation date	Disembarkation date	Boarding period
1st semester	1st phase	01st Mar. 2021	23rd Apr. 2021	53 days
	2nd phase	25th Apr. 2021	25th Jun. 2021	61 days
2nd semester	1st phase	29th Aug. 2021	22nd Oct. 2021	54 days
	2nd phase	24th Oct. 2021	17th Dec. 2021	54 days
Average				55.5 days

2.3 Status of consignment training in KMOU

Students assigned to consignment training prepare for boarding according to the guidance of the shipping companies by embarkation date, and board the merchant ships to experience consignment training. The department in charge of the university is monitoring consigned trainees through SNS in accordance with Article 6 of the on-board training operation guidelines (MOF, 2022). Consigned trainees report the date and place of embarkation and disembarkation, ship name, consigned shipping company, port of call, etc. by time. Therefore, based on the data reported by the consigned trainees through SNS, the consignment training environment in 2021 was checked.

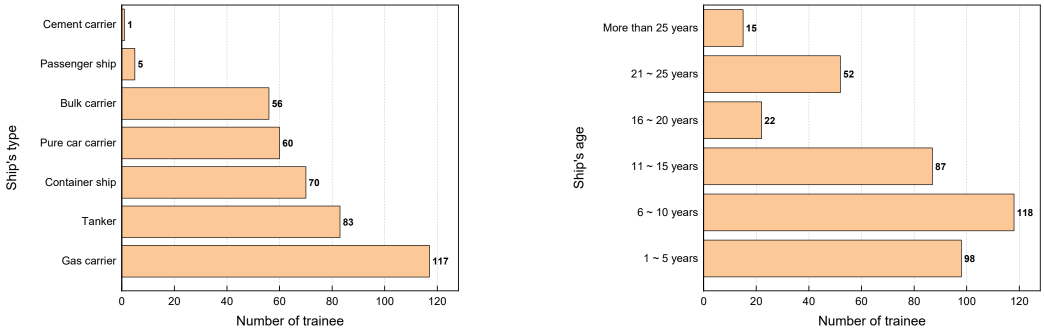


Figure 1 Ship's type and age of consignment training in 2021

As a result of checking the specifications of the vessels used for consigned trainees, the vessel to which the most consigned trainees were assigned was a gas carrier with an age of 6 to 10 years. The number of trainees aboard each vessel ranged from a minimum of 1 to a maximum of 4.

The table below is a descriptive statistical analysis of the consignment training days per semester based on the embarkation and disembarkation dates of consigned trainees in 2021. As a result of the analysis, it was confirmed that the 1st semester consigned trainees trained for a minimum of 101 days and a maximum of 246 days, with an average of 167 days. In the case of consigned trainees in the 2nd semester, it was confirmed that they embarked for a minimum of 78 days and a maximum of 219 days, with an average of 154 days.

Table 2 Boarding period of consignment training in 2021

Item	Value	
	1st semester	2nd semester
Number of observations	164	209
Minimum	101	78
Maximum	246	219
Average	166.68	154.20
Median	167	158
Standard deviation	30.1	32.9

2.3 Comparison of campus training and consignment training

As a result of examining the current status of campus training and consignment training in 2021, it was confirmed that there are differences in each training environment. First of all, comparing the duration of the on-board training, trainees boarded the training ship for an average of 56 days, but the consigned trainees boarded the merchant ship for an average of 161 days, confirming that there was a difference of more than 100 days. In addition, there is an inborn difference in the environment between the training ship and the merchant ship. Therefore, it is judged that there will be a significant difference in the trainees' experience and navigational skills depending on the type of training.

3. Investigation of collision risk perception

In this chapter, the students' perception of collision risk was evaluated, and the level of collision risk perception of the trainees was evaluated by comparing it with the that of ship operators calculated using the PARK (The Potential Assessment of Risk) Model, a maritime traffic risk model in Korea.

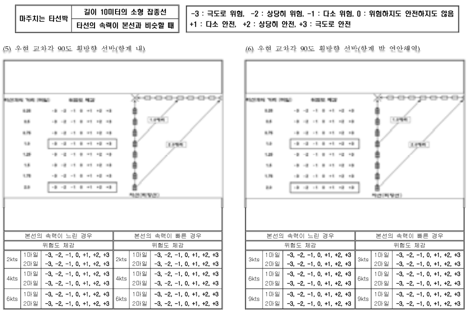
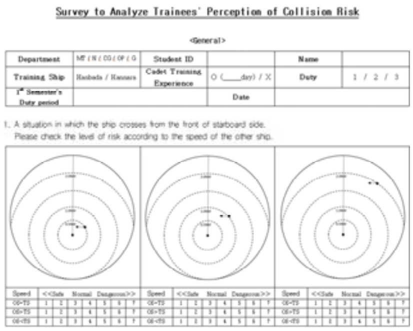
3.1 Methods of investigation of collision risk perception

3.1.1 Methods of investigation of collision risk perception for trainee

In order to investigate the trainees' perception of collision risk, a survey was conducted on about 110 deck trainees aboard the KMOU training ship (HANBADA, HANNARA) in the 2nd semester of 2021. The survey was conducted a total of five times from September 4, 2021, when the trainees embarked, to December 17, 2021, when they disembarked.

When composing the questionnaire, the questionnaire used in the PARK Model, a maritime traffic risk model in Korea, was referred to. The PARK (The Potential Assessment of Risk) Model is a model that reflects the characteristics of the Korean coastal region and the consciousness of ship operators (MLTM, 2011). At the time of development of PARK Model, a questionnaire was constructed with major items extracted through literature and survey. Therefore, it was judged that it was appropriate to refer to the questionnaire in this study to extract the perception of collision risk of Korean trainees.

Table 3 Sample of questionnaire for PARK Model and trainee

	 Survey to Analyze Trainees' Perception of Collision Risk
PARK Model	Trainee

3.1.2 Maritime traffic risk model (PARK Model)

In this study, the PARK Model, a maritime traffic risk model, was used for the perspective of a ship operators to verify the trainees' level of perception of collision risk by comparing trainees' perceived collision risk. The reason that the maritime traffic risk model was used to recognize the collision risk of ship operator is because the risk calculation formula of the model is based on a survey conducted on actual Korean ship operators (MLTM, 2011).

The PARK Model was constructed in consideration of factors that could affect maritime traffic safety by analyzing the data collected after conducting a survey on Korean ship operators. In the PARK Model, the maritime traffic risk between ships is calculated as a quantitative value as in equation below.

$$\begin{aligned}&Risk\ value = 5.081905 + type\ \ factor + ton\ \ factor + length\ \ factor\\&+ width\ \ factor + carrer\ \ factor + license\ \ factor + position\ \ factor\\&+ (0.002517 \times LOA) + crossing\ \ factor + side\ \ factor + in/out\ \ harbor\\&factor + speed\ \ factor - (0.004930 \times speed\ \ difference) - (0.430710 \times distance)\end{aligned}$$

However, the risk of PARK Model is adjusted in consideration of the ship's length, CPA, and TCPA. Finally, when determining the collision risk between ships, the lower of the adjusted risks is adopted (Ngyuen, 2014).

3.2 Investigation and analysis of collision risk perception
3.2.1 Changes in trainee's collision risk perception

The survey was conducted a total of 5 times, but the questionnaires used for the analysis were the questionnaires on September 4, 2021, when trainees boarded, and October 22, 2021, when they disembarked. This is because a semester was divided into 1st and 2nd phases due to COVID-19, and there was a change in the number of students participating in the survey. Paired t-test was conducted to confirm the change in the trainees' perception of collision risk over time with valid responses. The t-test is a statistical technique used to test the mean difference between two groups, and the paired t-test is used when the first and second scores of a group are related to each other (Chung, 2014). For analysis, Microsoft Excel and Origin Pro 2022 were used.

Table 4 t-test result of collision risk of trainees

Collision risk situation			1st survey	2nd survey	t	df	P value
Encounter	Distance	Speed					
045° Crossing	0.5 nm	OS = TS	6.395	6.558	-1.486	85	0.141
045° Crossing	0.5 nm	OS > TS	5.651	6.209	-2.999	85	0.004*
045° Crossing	0.5 nm	OS < TS	5.860	6.244	-2.273	85	0.026*
045° Crossing	1.0 nm	OS = TS	5.709	5.849	-0.888	85	0.377
045° Crossing	1.0 nm	OS > TS	5.233	5.500	-1.323	85	0.189
045° Crossing	1.0 nm	OS < TS	4.907	5.384	-2.456	85	0.016*

045° Crossing	2.0 nm	OS = TS	3.419	4.198	-3.378	85	0.001*
045° Crossing	2.0 nm	OS > TS	4.442	4.500	-0.237	85	0.813
045° Crossing	2.0 nm	OS < TS	3.128	3.826	-2.910	85	0.005*
135° Crossing	0.5 nm	OS = TS	3.977	4.907	-3.102	85	0.003*
135° Crossing	0.5 nm	OS < TS	5.209	5.698	-2.058	85	0.043*
135° Crossing	1.0 nm	OS = TS	3.314	4.047	-2.734	85	0.008*
135° Crossing	1.0 nm	OS < TS	4.337	4.860	-2.002	85	0.048*
135° Crossing	2.0 nm	OS = TS	2.267	2.860	-2.655	85	0.009*
135° Crossing	2.0 nm	OS < TS	3.116	3.407	-1.183	85	0.240
315° Crossing	0.5 nm	OS = TS	6.360	6.442	-0.619	85	0.538
315° Crossing	0.5 nm	OS > TS	5.837	6.209	-1.973	85	0.052
315° Crossing	0.5 nm	OS < TS	6.047	6.314	-1.770	85	0.080
315° Crossing	1.0 nm	OS = TS	5.558	5.663	-0.629	85	0.531
315° Crossing	1.0 nm	OS > TS	5.523	5.663	-0.677	85	0.500
315° Crossing	1.0 nm	OS < TS	4.977	5.372	-2.161	85	0.033*
315° Crossing	2.0 nm	OS = TS	3.395	4.035	-2.791	85	0.006*
315° Crossing	2.0 nm	OS > TS	4.233	4.337	-0.396	85	0.693
315° Crossing	2.0 nm	OS < TS	3.105	3.744	-2.813	85	0.006*
225° Crossing	0.5 nm	OS = TS	4.360	4.977	-2.172	85	0.033*
225° Crossing	0.5 nm	OS < TS	5.314	5.698	-1.687	85	0.095
225° Crossing	1.0 nm	OS = TS	3.616	4.116	-1.960	85	0.053*
225° Crossing	1.0 nm	OS < TS	4.419	4.942	-2.129	85	0.036*
225° Crossing	2.0 nm	OS = TS	2.512	2.919	-1.688	85	0.095
225° Crossing	2.0 nm	OS < TS	3.302	3.535	-0.930	85	0.355
000° Head-on	0.5 nm	OS = TS	6.640	6.686	-0.390	85	0.697
000° Head-on	0.5 nm	OS > TS	6.640	6.698	-0.449	85	0.655
000° Head-on	0.5 nm	OS < TS	6.779	6.698	0.701	85	0.485
000° Head-on	1.0 nm	OS = TS	6.012	6.035	-0.135	85	0.893
000° Head-on	1.0 nm	OS > TS	5.988	6.047	-0.319	85	0.750
000° Head-on	1.0 nm	OS < TS	6.128	5.965	0.961	85	0.339
000° Head-on	2.0 nm	OS = TS	4.453	4.547	-0.395	85	0.694
000° Head-on	2.0 nm	OS > TS	4.547	4.616	-0.278	85	0.782
000° Head-on	2.0 nm	OS < TS	4.756	4.616	0.585	85	0.560
180° Overtaken	0.5 nm	OS < TS	5.965	5.977	-0.061	85	0.952
180° Overtaken	1.0 nm	OS < TS	4.744	4.930	-0.923	85	0.359
180° Overtaken	2.0 nm	OS < TS	3.186	3.593	-1.594	85	0.115

OS: Own Ship, TS: Target Ship, $p^{*}<0.1$, $p^{**}<0.05$

As a result of the analysis, it was found that the trainees felt a higher level of risk for collision risk situations with other ships as the boarding period elapsed. This is thought to be because the trainees had a higher burden of encounters with other ships by skillfully recognizing the surrounding situation through several sailing experiences. In consequence of t-test, there were a total of 16 situations that were statistically significant, and no statistically significant results were found in the head-on or overtaken situation. Through this, it was identified that the trainees always judged that it was dangerous or safe to meet head-on or to be overtaken.

In addition, the survey response range of trainees was clustered at disembarkation rather than embarkation in close proximity to other vessels. Through this, it was confirmed that the trainees' perception of collision risk was becoming similar due to the sailing experiences.

3.2.2 Comparison of collision risk between trainee and ship operator

In order to check the degree of trainees' collision risk perception, the trainees' perception of collision risk and the ship operators' perception of collision risk by PARK Model were compared. The average risk value of trainees was used to compare the risk of the PARK model.

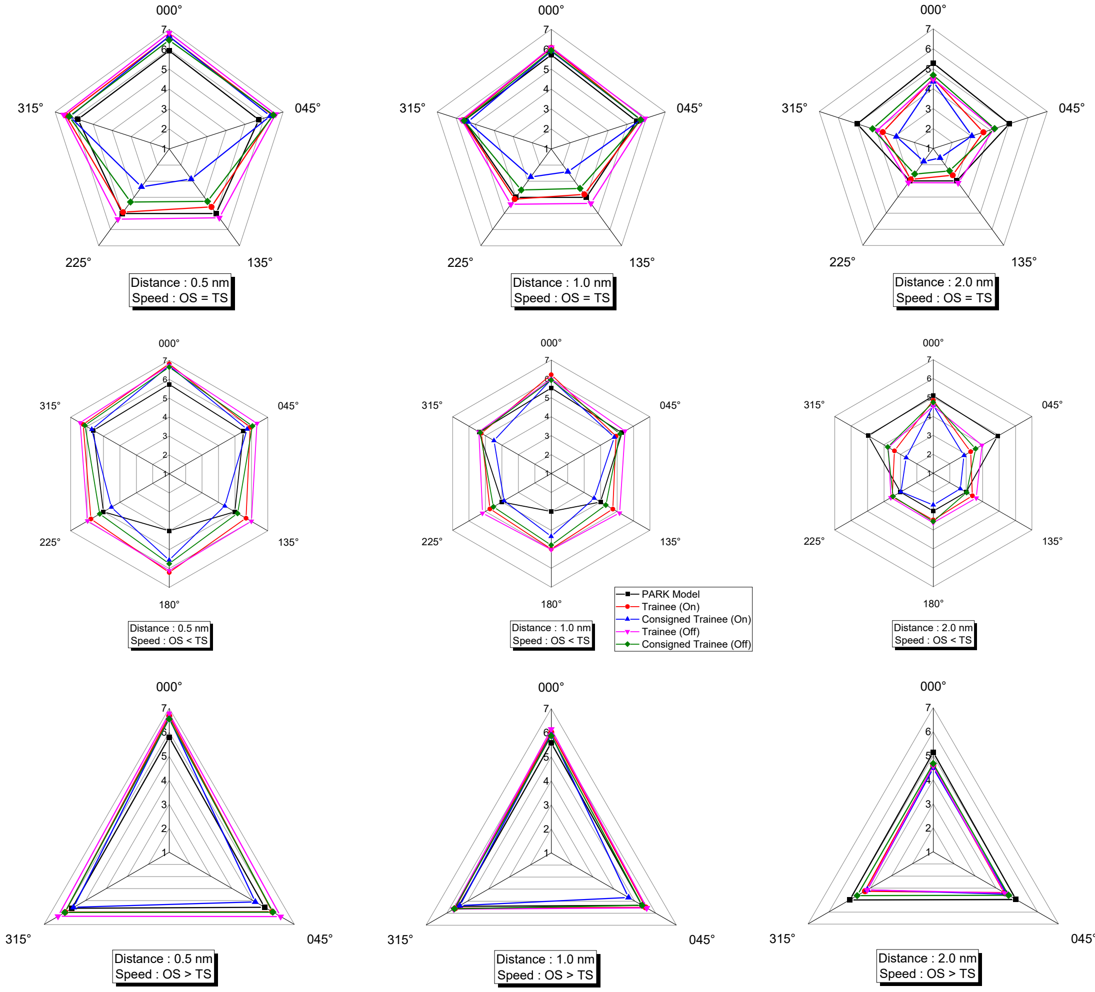


Figure 2 Comparison of collision risk perception

As a result of comparing the risk of each trainee at the time of embarkation and disembarkation and the risk of the ship operator through the PARK Model for 42 collision risk situations, the closest to the risk of the ship operator was the consigned trainee. This seems to be because the consigned trainees spent more time on the navigational watch in the field than trainees in the 1st semester of 2021.

4. Survey for introduction of collision prevention education

Previously, it was confirmed that the experience of sailing had a great influence on the perception of collision risk through the analysis of the trainees' perception of collision risk. However, it was judged that collision prevention education is necessary because the on-board training resources that allow all deck trainees to experience sailing for an enough amount of time were limited. Therefore, it was investigated what is the proper training method of the effective collision prevention education for deck trainees.

4.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making that systematically quantifies the relative importance of various alternatives in a problem situation with multiple evaluation criteria (Min, 2015). AHP allows decision makers to consider subjective, quantitative and qualitative factors in addition to objective factors in comparing and evaluating the preferences of alternatives.

First, AHP analysis implements hierarchical structuralize for each problem and performs binary comparison between decision-making factors for each layer of the hierarchical structure. Afterwards, using the consistency ratio, it is measured whether the binary comparison matrix is consistent or not. Then, the eigenvalue method is applied to the consistent binary comparison matrix to derive the relative importance and relative preference of decision-making factors for each layer. The eigenvalue application method is as shown in equation below.

$$A \times w = \lambda_{\max} \times w$$

where, A : n * n binary comparison matrix

w : the relative importance and relative preference of decision-making factors

λ max : the biggest λ in the n eigenvalue methods

n : the number of alternatives in a same layer

Finally, the overall preference of alternatives is calculated by combining the relative importance and relative preference of all decision-making factors, and the selection of alternatives or the priority of alternatives is determined according to the overall preference.

4.2 Survey construction method

First, in order to select an appropriate collision prevention education method, the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW, 1978) and the education status of the maritime educational institutions were analyzed. Accordingly, the identified factors were stratified to derive decision-making factors.

4.2.1 Review of legal standards

Table A-II/1 of Chapter 2 in Part A of the STCW (International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1978) Convention defines the minimum standard specification of the seaman's competence for officers in charge of the navigational watch in ships of 500 gross tonnage or more (IMO, 1978). Through Table A-II/1, competences related to collision prevention include maintaining a safe navigation watch and the use of radar and ARPA to maintain a safe navigational watch. Knowledge required for this competence includes complete knowledge of the International Regulations for Preventing Collisions at Sea, and methods to prove this include test, experience in the field, experience on a training ship, simulator training, and laboratory equipment training.

4.2.2 Review of collision prevention education status

KMOU provides various essential job training to students as a maritime educational institution. Among training courses, it was confirmed that radar simulation and automatic collision prevention education were being implemented as collision prevention education (KMOU, 2022).

Table 5 Status of collision prevention education in KMOU

<table>
<tr><th>Subject name</th><th>Related rules</th><th>Object</th><th>Training period</th><th>Teaching method</th></tr>
<tr><td rowspan="4">Radar simulation & automatic collision prevention Training</td><td>STCW convention</td><td rowspan="2">Sophomore in college of maritime sciences</td><td rowspan="4">48 hours</td><td rowspan="2">Theoretical education</td></tr>
<tr><td>Ship personnel act</td></tr>
<tr><td>Seafarer’s act</td><td rowspan="2">Senior in college of maritime sciences</td><td rowspan="2">Simulation training (+ theoretical education)</td></tr>
<tr><td>Designated educational institution’s Rule</td></tr>
</table>

As shown in the table, theoretical education is conducted for the sophomore’s collision prevention education, and in the senior, theory education and training are mixed for collision prevention education. As a result of interviewing the faculties in charge of each subject, it was found that the theoretical education is operated by discussion, providing audiovisual materials and professional knowledge by law or books, and the training is conducted using a ship handling simulator. Through the status of maritime educational institutions in Korea, it was confirmed that not only training, but also theoretical education was provided as collision prevention education. Also, it was recognized that the theoretical education is a very important process as it is the work to build the foundation of knowledge before training.

4.2.3 Construction of AHP model

Based on the results of checking the legal standards and education status related to collision prevention education, a brainstorming was conducted with a group of experts including maritime education experts and ship operators to derive the following AHP structure tree.

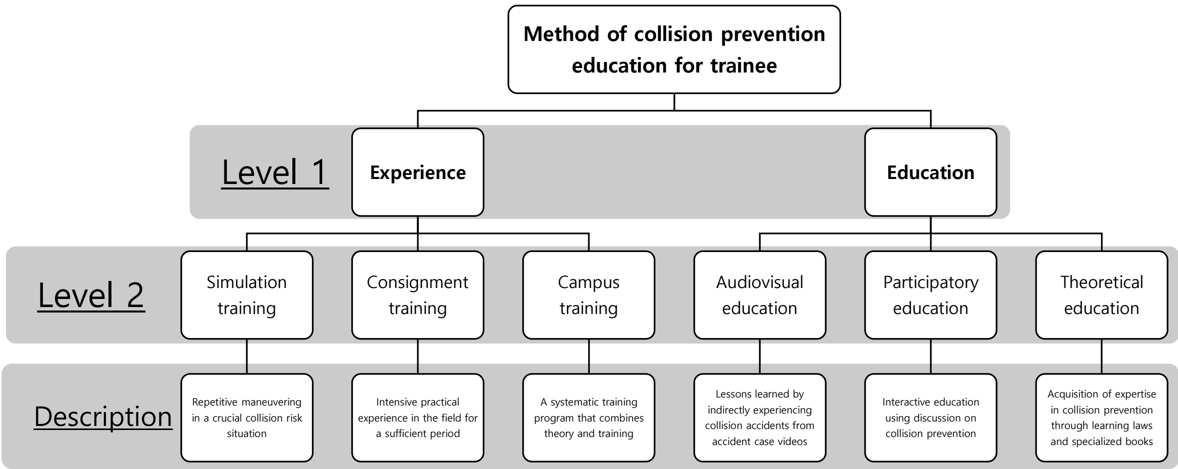


Figure 3 Structure tree for AHP analysis

4.2.4 Conduction of survey

In the survey based on the AHP model, ship operators composed of captains and marine pilots and educators who provided training related to collision prevention and ship operation at educational institutions participated. The survey was conducted as a face-to-face survey, and briefing was conducted on AHP techniques and response methods before survey.

4.3 Results

4.3.1 General characteristics of respondents

In this study, the total number of respondents in the AHP-based survey was 15. All respondents were male, and the age group who answered the most was in their 50s, followed by those in their 40s, 60s and over, and 30s. It was confirmed that the experience of the respondents at each institution including the on-board experience was 25 years or more, 20-25 years, 15-20 years, and 10-15 years in the order.

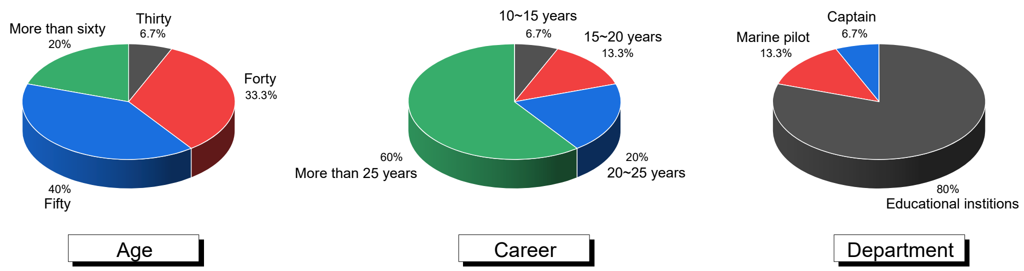


Figure 4 General characteristics of respondents

AHP must implement the process of measuring the consistency ratio to see if the survey results conducted by decision makers are consistent (Min, 2015). To obtain the consistency ratio, first multiply the binary comparison matrix and the relative importance vector calculated from the binary comparison matrix. The multiplication result is a column vector. Each element of the column vector is subdivided into the relative importance of the alternative corresponding to each element. Then, the arithmetic mean of the obtained values is calculated. Finally, the consistency index (CI) and the consistency ratio (CR) is calculated according to the equation below.

$$CI = \frac{(\lambda_{\max} - n)}{(n-1)}$$

where, λ max : the biggest λ in the n eigenvalue methods
n : the number of alternatives to be compared

$$CR = \frac{CI}{RI}$$

where, RI : Random Index

The consistency ratio (CR) was calculated for the questionnaires of all respondents, and the consistency ratio of 12 out of 15 copies was calculated to be less than 0.1. A second questionnaire was conducted for the three copies calculated as invalid responses, and all three copies had a consistency ratio of 0.1 or less, which was used for the analysis of all questionnaires.

4.3.2 Survey analysis results

As a result of measuring the relative importance and priority of each element based on the valid questionnaire, the importance of experience was calculated to be 0.6831 and education was 0.3169 for the first level. Therefore, it was found that experience, which is the aspect of training, was judged as twice as important as education.

As a result of analyzing the relative importance and priority of the elements of the second level, the importance of simulation training (0.2814) was the highest among all factors, followed by consignment training (0.2417), audiovisual education (0.1710), and campus training (0.1600), participatory education (0.0973), and theoretical education (0.0486) were confirmed in order.

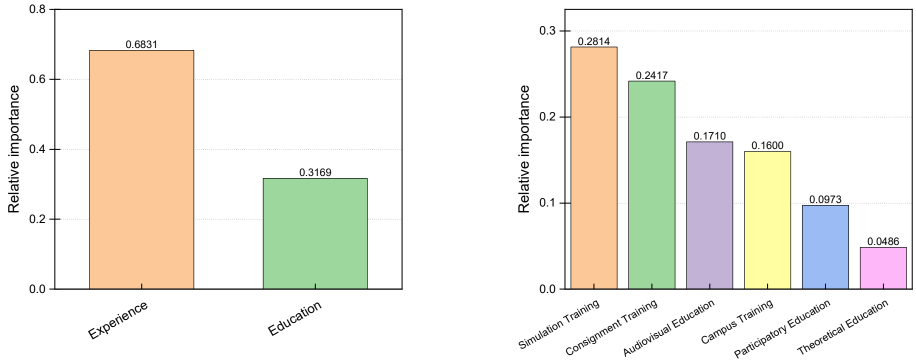


Figure 5 Relative importance of factors

4.4 Discussion

In this chapter, an AHP analysis-based survey was conducted for drawing the appropriate training method of collision prevention education for trainees and the valid responses were analyzed.

As a result of the analysis, it was confirmed that the importance was high in the order of simulation training, consignment training, audiovisual education, campus training, participatory education, and theoretical education. Accordingly, it was judged that simulation training was the most suitable method of collision prevention education for trainees.

The fact that simulation training was selected as the most important factor is that it allows trainees to directly participate in collision risk situations and train repeatedly. Also, in the United States, simulation training is recognized as 1.5 times that of actual on-board training, so that simulation training has already been introduced as a form of on-board training and is being actively utilized (USCG, 2022). Therefore, it is expected that a huge positive effect will occur if the simulation training is introduced into the training course of training ship.

However, it is not that the theoretical education, which was analyzed with the lowest importance in the survey results, is not appropriate as the collision prevention education. This can be confirmed by the fact that all methods in the second level are mixed and operated in the current education status. Therefore, when operating collision prevention education, it is desirable to arrange simulation training as the main course and to mix and conduct various theoretical education methods in parallel.

5. Conclusion

This study aims to raise the need of introducing collision prevention education in the training course of the training ship by identifying the current status of training in training ship and verifying the trainees' perception of collision risk. The analysis results are as follows.

(1) It was recognized that there is a significant difference in the environment and boarding period between campus training and consignment training by investigation of the status of on-board training in 2021.

(2) As the elapse of the boarding period, it was found that the trainees felt a higher level of risk and a burden in encounters with other ships. Also, trainees judge a head-on or overtaken situation as a very dangerous or safe at all times. Moreover, it was confirmed that the perception of collision risk between trainees became similar as the boarding period elapsed.

(3) As a result of comparing the risks of trainees and ship operators through PARK Model, it was found that,

on average, trainees reacted more sensitively to collision risk situations than ship operators for each encounter situation. However, the consigned trainees in the 1st semester of 2021 were most similar to the collision risk perception tendency of ship operators.

(4) By collision risk perception analysis, it was verified that sailing experience is very important to trainees, but in reality, on-board training resources were insufficient. Therefore, author asserts that the introduction of collision prevention education is necessary. Accordingly, AHP questionnaire was conducted to select the most effective collision prevention education method. As a result of the AHP survey analysis, it is judged that simulation training, which is an experience-oriented education, is the most suitable as a method of collision prevention education.

It is judged that this study can be used as a basic data for developing collision prevention education and training using simulators if various factors are considered in the scenario development in the future survey, more samples are secured, and a sufficient survey period is provided.

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