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RESEARCH ARTICLE

The non-technical skills of bridge officers on ship navigation: An assessment in terms of interpersonal skills

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Abstract

Objectives: This study aims to examine the effects interpersonal skills (leadership and communication) as part of non-technical skills on bridge officers at critical times and bridge watches. **Methods/Statistical analysis**: A total of 40 questions, out of which 25 questions with 5-point Likert scales, 2 questions with multiple choices, and 13 demographic questions were filled by 400 seafarers via online survey method. Explanatory factor analysis was performed using Varimax, Kaiser Normalization Rotation Method, and Principal Components Analysis to reduce survey's items in low dimensions. Scree plot test, eigenvalues-greater-than-1 rule, explanatory percentage of the total variance, Cronbach's Alpha Coefficient, Split half method Spearman-Brown correlation coefficient were used in factor analysis. **Findings**: Some dimensions have significant relationships. There is a weak positive statistical correlation between teamwork skills and sharing workload, leadership, personal attitudes, operational safety decision-making, communication. This result supports the hypothesis 1 and hypothesis 2 that there is a relationship between teamwork skills and communication, personal attitudes. So, while the leadership is increasing, personal attitudes, operational safety decision-making, communication will be getting better supporting hypothesis 3 which is revealed that there is a relationship between leadership and communication. Finally, it is found that there is a weak positive statistical correlation between operational safety decision-making and communication. **Applications**: The psychology and non-technical skills of the bridge team and other crew members play an important role in minimizing the occurrence marine accidents.

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Keywords: Non-technical skills; interpersonal skills; bridge resource management; human factor

1 Introduction

The maritime industry has concentrated on improving ship structures and ensuring the enduring quality of the ship's framework for the past 40 years [1]. The working environments of vessels have improved greatly when compared to older designs from the past. However, the ongoing occurrence of marine accidents shows that technology and technical details only provide a certain level of development. The human factor is still the main cause of marine accidents [2]. The psychology and non-technical skills (NTS) of the bridge team and other crew have a fundamental role in marine accidents. Some researchers, apart from technical factors, argue that most of the accidents are caused by inadequacy of seafarers to respond properly to cases on the ship [3,4].

The concept of non-technical skills first emerged in the aviation field [5]. Aviation research has shown that focusing only on technical capabilities will be insufficient for safety management. Studies conducted in other fields related to this concept have shown similar results with the studies in aviation [6–8]. For this reason, non-technical skills are an integral part of technical skills. Non-technical skills are identified as cognitive and interpersonal skills and their corresponding conceptual and behavioral content. Situation awareness, workload management, and decision-making are cognitive abilities. Communication and leadership are interpersonal skills [9].

NTS principles, called Crew Resource Management (CRM) in aviation, have been transferred to the maritime as Bridge Resource Management (BRM) training [3]. BRM tries to minimize human error on ships using NTS. BRM is developed by taking into account human errors defined as interpersonal communication, decision-making and leadership deficiencies in marine accidents. It has been stressed in the Standards of Training, Certification and Watchkeeping for Seafarers (STCW) Code since 2010 [10]. According to BRM training stated in STCW code, bridge members and engineers are required to gain qualification with a certification. Not only seafarers can be considered to acquire these qualifications by completing BRM training, but also approved in-service experience can be assessed for sufficient BRM Skills. Although some of NTS status (situation awareness, decision-making, workload management, and communication) have been changed from "recommended" to "required," for bridge officers in STCW, studies on BRM training are still insufficient comparing to CRM training research [9,11].

Some research has been carried out on the cognitive and interpersonal skills of NTS in maritime sector [9]. However, studies in the interpersonal skills of bridge officers are quite limited and undigested [12–15]. It is also unclear how non-technical skills are interconnected in the maritime environment [16]. Interpersonal skills are very important for the safe navigation of a ship. The master is the leader of the ship and influences the behavior and activities of the crew. The master should encourage the crew to identify and report errors. Announcing near misses and challenging risky acts provide fewer occupational injuries and better navigational safety performance [17].

The working environment onboard requires teamwork, a high degree of cooperation, knowledge sharing, and crew members' confidence in each other's professional achievement and social skills. The length of the contract duration, difficult working conditions, and the lack of social life cause stress and burnout and negatively affect the performance of seafarers [18]. These cause communication disorders on the ship and reveals safety risks in terms of "human factor".

When examined NTS studies on interpersonal skills, none of them conducted a study under the leadership of the ship master dealing with the communication and some sub-factors of bridge officers. For this reason, the study aimed to examine the effects of interpersonal skills (leadership and communication) of NTS of bridge officers at critical times and bridge watches. It is thought that it will shed light on future NTS studies and contribute to BRM training. In this direction, three hypotheses are discussed.

Hypothesis 1: An effective bridge team coordination with members who consider each other's personality traits could only be achieved when team members clearly discuss different opinions to resolve conflicts.

Hypothesis 2: Bridge team members who have psychological stress or physical problems before or during a watch often feel embarrassed if they make a mistake in front of bridge team members.

Hypothesis 3: Bridge team members who think the master should be aware of and responsive to personal problems of all deck crew, need encouragement from the master to ask questions under normal sea conditions and emergencies.

2 Materials and Methods

2.1 Data collection and sample

A total of 40 questions, consisting of 25 questions of 5-point Likert scales, 2 questions of multiple choices, and 13 demographic questions were filled by 400 seafarers via online survey method.

All participants are volunteers. Table 1 shows the demographic characteristics of the participants. According to Table 1, 274 of 400 (68.5%) participants are men. It is known that the majority of the people working in the maritime industry are men. 245 (61.2%) participants are married. 177 of 400 participants (44.2%) are between 25-34 years and the majority of the rest are aged

18-24. Participants are from 5 different countries and the greatest participation (42%) is from the USA.

Table 1. Demographic characteristics of the participants (N= 400)

		N	%
Gender	Men	274	68.5
	Women	125	31.2
	Prefer not to say	1	0,3
Marital Status	Married	245	61.2
	Single	139	34.8
	Divorced	6	1.5
	Widowed	10	2.5
Age (years)	18-24	153	38.2
	25-34	177	44.2
	35-44	62	15.5
	45-54	7	1.8
	55+	1	0.3
Country	USA	169	42.2
	India	84	21
	Turkey	54	13.5
	Brazil	50	12.5
	Russia	43	10.8

25 questions of 5-point Likert scale (1: Strongly Disagree- 5:Strongly Agree) are asked to participants. Table 2 shows the distributions of all the items and the overall survey score. The median values of the items show that the participants' opinions are almost same and "Agree".

Table 2. Distribution of scale data

	Mean ±SD	Med (Min.-Max.)
q16. The master must take conn and stay on the bridge in emergencies and abnormal situations.	3.94±0.87	4(1-5)
q17. Masters should encourage the bridge team members to ask questions under normal sea conditions and emergencies.	3.80±0.80	4(1-5)
q18. Even if it is thought to be the best for the interests of the company, the bridge team should never violate watchkeeping standards.	4.05±0.88	4(1-5)
q19. The master should be aware of and responsive to the personal problems of all deck crew.	3.79±0.96	4(1-5)
q20. I expect to be consulted on matters that affect my job performance.	3.85±0.93	4(1-5)
q21. Senior officers deserve more wages and privileges than other crew.	3.99±0.88	4(1-5)
q22. When my workload is excessive(or approaching the limit), I notify bridge team members.	3.92±0.87	4(1-5)
q23. A briefing on procedures and decisions after each voyage is an important part of ensuring and maintaining an effective bridge team and deck crew coordination.	3.89±0.96	4(1-5)
q24. Young and inexperienced officers should not question the decisions of the master or senior officers.	3.84±0.96	4(1-5)
q25. I tend to make decision-making mistakes in emergencies.	3.83±0.93	4(1-5)
q26. It is better to agree with other team members than to express a different opinion.	3.73±1.08	4(1-5)
q27. The bridge team should share the responsibility of prioritizing the activities in cases where the workload is intense.	3.85±0.96	4(1-5)
q28. Successful management of the vessel depends primarily on the capability of the master.	3.98±0.88	4(1-5)
q29. If I find that there is a problem with the operation/management of the vessel, I will notify the issue without thinking about who will be affected.	3.74±0.99	4(1-5)
q30. I'm embarrassed if I make a mistake in front of bridge team members.	3.89±0.99	4(1-5)
q31. My efficiency drops significantly when I am stressed or tired.	4.03±0.88	4(1-5)
q32. In unusual situations that may occur on the vessel, I trust my superiors about what to do.	3.94±0.85	4(1-5)
q33. Team members should not question the master's decisions or actions, unless they endanger the safety of the vessel and crew members.	3.74±1.03	4(1-5)

Continued on next page

Table 2 continued

q34. Team members should clearly discuss different opinions to resolve conflicts.	3.87±0.92	4(1-5)
q35. The chief officer should never take control of the vessel, except when the master is experiencing complete incapacity.	3.93±0.92	4(1-5)
q36. A true professional bridge team member can leave personal problems behind during a watch.	3.69±1.02	4(1-5)
q37. Bridge team members should feel compelled to report their psychological stress or physical problems to other team members before or during a watch.	3.69±1.05	4(1-5)
q38. Written procedures are required in all sea, wind, and traffic conditions.	3.87±0.92	4(1-5)
q39. Personal problems can negatively affect my performance.	3.84±0.91	4(1-5)
q40. An effective bridge team coordination requires team members to consider each other's personality traits.	3.58±0.99	3(1-5)
Overall Score	3.85±0.43	3.92(1.4-4.6)

2.2 Statistical methods

Descriptive statistics were used to define continuous variables. Frequencies (n) and percentages (%) were used to define categorical variables.

Explanatory Factor Analysis (EFA) was conducted to examine the validity of the survey. Bartlett's test of sphericity and Kaiser Meyer Olkin's measure of sampling adequacy was used as pre-tests of explanatory factor analysis. Besides, the anti-image correlation matrix was examined in terms of sample size adequacy. Explanatory factor analysis was performed using Varimax, Kaiser Normalization Rotation Method, and Principal Components Analysis. Scree plot test, eigenvalues-greater-than-1 rule, explanatory percentage of total variance were used to decide the number of factors.

Cronbach's Alpha Coefficient was used to evaluate internal reliability. Split half method Spearman-Brown correlation coefficient was used to evaluate the inter-rater reliability.

EFA was performed to evaluate the validity of the survey. Some pretests were used before factor analysis. Kaiser-Meyer-Olkin (KMO) criteria were examined for sample adequacy. The KMOindex is an index that compares observed correlation coefficients and partial correlation coefficients. In this study, the KMO criterion should be above 0.60 indicates that the sample size is suitable for factor analysis.

The Bartlett test evaluates the diagonal elements of the correlation matrix to 1 and non-diagonal terms to be 0. This test also shows the suitability of the data for multiple normal distribution. In this study, we can say that the population correlation matrix is not a unit matrix since the Bartlett test is calculated at 0.05 significance level and p value should below 0.05. So, all EFA assumptions have been provided.

3 Results

The survey is found reliable (Cronbach's alpha= 0.840) and inter-rater reliability is sufficient (Spearman-Brown coefficient r = 0.880). So, the validation analysis can be utilized. The assumptions of the EFA are provided (KMO=0.845, Bartlett test p<0.001). The diagonal values of the anti-image correlation matrix range from 0.571 to 0.933. This range indicates that the sample size is suitable for factor analysis. Total variances are indicated in Table 3 . The eigenvalues of the first 7 factors are more than 1. In this study, 7 factors explain 52.1% (>50%) of the total variance.

Table 3. Rotation sums of squared factor loadings

	Percent Variance	Cumulative%
Factor1	15.738	15.738
Factor2	7.165	22.902
Factor3	6.186	29.088
Factor4	5.886	34.974
Factor5	5.751	40.725
Factor6	5.711	46.436
Factor7	5.688	52.124

Figure 1 shows the determination of the number of factors. Since there is a very distinct decrease in the transition from the 7^{th} dimension to the 8^{th} dimension, 7 dimensions are determined. These components are summarized all 25 items.

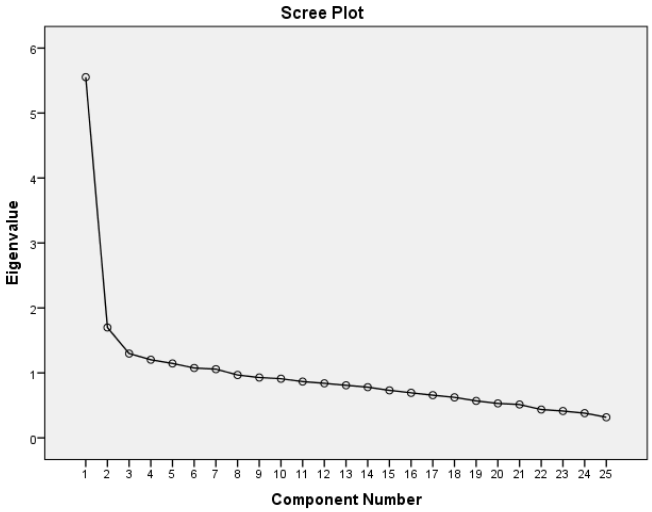

Fig 1. Scree plot

According to EFA, the survey consists of 7 sub-scales. Rotated component factor loading are shown in Table 4 to determine the that converged in the same factor. 1st factor includes 19, 24, 26, 29, 33, 36, 37 and 40th items. 2nd factor includes 22, 23 and 27th items. 3rd factor includes 20, 28 and 38th items. 4th factor includes 16, 21 and 31th items. 5th factor includes 30, 32 and 39th items. 6th factor includes 18 and 35th items (Table 4).

Table 4. Rotational components matrix

Items	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
q16	-.137	.183	.336	.444	.374	-.160	-.012
q17	.186	-.042	.170	.135	-.069	.451	.476
q18	.078	.337	-.026	.084	-.151	.589	.229
q19	.680	.064	.125	-.028	.019	.124	.131
q20	.229	.204	.401	-.302	.102	.282	.126
q21	.050	-.052	.028	.637	.140	.209	.004
q22	.116	.485	.074	.064	.095	.035	.084
q23	.171	.614	.265	.131	.004	.010	-.061
q24	.540	.006	-.144	-.106	.235	.019	.232
q25	.202	.349	.353	.051	-.102	.099	.378
q26	.766	.024	.166	.046	.057	.040	.049
q27	.146	.574	-.219	-.144	.354	.185	.052
q28	.086	-.014	.698	.247	.071	.168	.036
q29	.635	.284	-.147	.013	-.063	.215	-.013
q30	.332	.073	.167	-.224	.542	-.040	-.011
q31	.149	.209	.025	.681	-.206	-.027	.102
q32	-.052	-.133	.052	.129	.408	.049	.613
q33	.618	.298	.213	.035	.142	.080	-.027
q34	.262	.260	.027	-.090	-.100	-.089	.658
q35	.175	-.008	.183	.052	.185	.713	-.169
q36	.669	.207	.271	.073	.036	-.087	.062
q37	.569	.279	-.060	.021	.185	.215	.164
q38	.251	.278	.476	-.245	-.015	-.010	.128
q39	.215	.167	-.027	.128	.643	.072	.025
q40	.684	-.002	.078	.082	.107	.072	.027

Rotation method: Varimax with Kaiser normalization

Table 5 shows the distributions of all the sub-factors. The median values of the sub-factors show that the participants' opinions are almost same and "Agree". The relationship between sub-factors are evaluated with correlation analysis.

These factors are named as the subjects that are related to. So, F1 is named as "teamwork skills", F2 is named as "sharing workload", F3 is named as "leadership", F4 is named as "efficiency of the officer", F5 is named as "personal attitudes", F6 is named as "operational safety decision-making", F7 is named as "communication".

Table 5. Distributions of sub-dimensions

	Teamwork skills	Sharing workload	Leadership	Efficiency of the officer	Personal attitudes	Operational safety decision-making	Communication
Mean+SD	3.72+0.69	3.88+0.62	3.9+0.62	3.98+0.59	3.89+0.61	3.99+0.7	3.83+0.62
Med. (Min.-Max.)	3.88 (1.25-4.88)	4 (1-5)	4 (1-5)	4 (1.33-5)	4 (1.33-5)	4 (1-5)	4 (1-5)

There is a weak positive statistical correlation between teamwork skills and sharing workload, leadership, personal attitudes, operational safety decision-making, communication. So, while the teamwork skill is improving, sharing workload, leadership, personal attitudes, operational safety decision-making, communication will be getting better. This result is supporting hypothesis 1 and hypothesis 2 which are revealed that there is a relationship between teamwork skills and communication, personal attitudes. There is a weak positive statistical correlation between sharing workload and leadership, personal attitudes, communication. So, while the sharing workload is increasing, leadership, personal attitudes, communication will be getting better. There is a weak positive statistical correlation between leadership and personal attitudes, operational safety decision-making, communication. So, while the leadership is increasing, personal attitudes, operational safety decision-making, communication will be getting better. This result is supporting hypothesis 3 that reveals that there is a relationship between leadership and communication. Finally, it is found that there is a weak positive statistical correlation between operational safety decision-making and communication (Table 6). The detailed explanation of the factors' relationship are given as follows with the items one by one.

Table 6. Correlation analysis of sub-dimensions

		Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
Factor1	**r**	1.000	**.160****	**.199****	.045	**.186****	**.134****	**.188****
	p		**.001**	**<0.001**	.372	**<0.001**	**.007**	**<0.001**
	n	400	400	400	400	400	400	400
Factor2	**r**		1.000	**.107***	.044	**.160****	.093	**.124***
	p		.	**.033**	.382	**.001**	.063	**.013**
	n		400	400	400	400	400	400
Factor3	**r**			1.000	-.035	**.160****	**.150****	**.226****
	p			.	.489	**.001**	**.003**	**<0.001**
	n			400	400	400	400	400
Factor4	**r**				1.000	.076	-.041	-.008
	p				.	.131	.412	.874
	n				400	400	400	400
Factor5	**r**					1.000	.039	.066
	p					.	.434	.185
	n					400	400	400
Factor6	**r**						1.000	**.111***
	p						.	**.027**
	n						400	400
Factor7	**r**							1.000
	p							.
	n							400

*p<0.05,**p<0.001, Spearman's rho correlation test

A weak positive statistical correlation is found between "The master should be aware of and responsive to personal problems of all deck crew" and "Masters should encourage the bridge team members to ask questions under normal sea conditions and emergencies". It is obvious that bridge team members who think the master is responsible for all problems on board, including an event caused by the personal problem of a crew member, also need to ask whatever is on their mind in any situation. Hence,

they think masters should encourage crew members to ask.

Results show that people who expect to be consulted on matters that affect their job performance, also think their personal problems can negatively affect their performance. There is a weak positive statistical correlation between factors "I expect to be consulted on matters that affect my job performance" and "Personal problems can negatively affect my performance".

Bridge team members who feel stressed or tired also feel the fear of making mistakes on their duties especially in front of other members. A weak positive statistical correlation is founded between factors "Bridge team members should feel compelled to report their psychological stress or physical problems to other team members before or during a watch" and "I'm embarrassed if I make a mistake in front of the bridge team members". The recent studies show that officers make mistakes during cargo operations under stress or factors such as long working hours, time pressure and fatigue [(19)].

There is also a weak positive statistical correlation between factors "An effective bridge team coordination requires team members to consider each other's personality traits" and "Team members should openly discuss different opinions to resolve conflicts." Participants who believe in personality traits and behaving each other member accordingly, also believe an effective and smooth workspace can only be achieved by discussing different opinions and communicating.

4 Discussion

Ships are complex and high-risk structures where human-related errors are seen in high rates, interdisciplinary relationships exist, and dependence on technical and non-technical skills is high. Non-technical skills closely related to factors shown in Table 5 are an important element in reducing human-induced errors and ensuring navigational safety. For this reason, the present study focused on interpersonal skills of bridge officers on ship navigation and bridge watch. According to our results, increased leadership can lead to increased communication, operational safety decision-making and effective teamwork. While the teamwork skill is improving, sharing workload, leadership, personal attitudes, operational safety decision-making, communication will be getting better. Moreover, while the sharing workload is increasing, leadership, personal attitudes, communication will be getting better. Finally, while operational safety decision-making is increasing, communication will be better. They all reflect our hypotheses.

It is aimed to stress the importance of interpersonal skills for a safe navigation of bridge officers in this study. Although IMO says it is "necessary" for officers to take the BRM training, it will be more effective to hold an examination at the end of the training as in aviation and for the officers to work on ships only when they pass this exam. This can be important in preventing ship accidents. Further, the training of non-technical skills is essential and to develop these skills and reduce the risk of error, the crew with different professional levels can be trained together, not separately for an active team work and communication. As we have mentioned earlier, studies on NTS in maritime are limited and NTS concepts are not totally explained. This study provides an explanation and understanding of the interpersonal skills of NTS with sub-factors in Maritime. Additionally, the results can contribute to BRM training and future studies.

5 Conclusion

Because of the frequent occurrence of human errors, the high-risk ship environment requires bridge officers with non-technical skills as well as technical skills. Leadership and communication are interpersonal skills of NTS, and they influence a safe ship navigation and bridge watch. In this study, the impacts of non-technical skills of bridge officers were examined in terms of interpersonal skills. According to results obtaining from the study, there is a weak positive correlation between leadership and communication. Furthermore, it is shown that there are sub-factors related to interpersonal skills which are teamwork skills, operational safety decision-making, teamwork skills, sharing workload, efficiency of officer and personal attitudes. These sub-factors have a positive effect on the bridge officers. It is found that there is a weak positive statistical correlation between teamwork skills and sharing workload, leadership, personal attitudes, operational safety decision-making, communication. Similarly, there is a weak positive statistical correlation between leadership and personal attitudes, operational safety decision-making, communication. Finally, there is a weak positive statistical correlation between operational safety decision-making and communication.

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