Multidisciplinary
SCIENTIFIC JOURNAL OF
MARITIME RESEARCH

University of Rijeka
Faculty of Maritime
Studies Rijeka

Multidisciplinarni
znanstveni časopis
POMORSTVO

Analysis of the level of knowledge and understanding of regulations for preventing collisions at sea

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ABSTRACT

The Regulations for Preventing Collisions at Sea (COLREG) is a collection of international legal standards adopted in order to avoid collisions at sea. Comprehensive knowledge of these rules is required for all who sail on the sea.
The ACTs project (Avoiding Collisions at Sea) investigates the current problems in applying these Rules and intends to develop a new online course making it simpler and easier to understand them. A COLREG questionnaire has been drawn up for research purposes. The purpose of the questionnaire is checking which rules are more difficult to understand.
In this paper, the authors analyse the level of understanding of the Rules in a group of secondary maritime school students. The survey results indicate that many of the basic principles of COLREG are neither understood nor applied.

ARTICLE INFO

Preliminary communication
Received 10 November 2015
Accepted 2 December 2015

Key words:
COLREG
ACTs project
COLREG questionnaire
Students

1 Introduction

The International Regulations for Preventing Collisions at Sea 1972, also known as "COLREGs", prescribe rules to be followed by all vessels at sea in order to prevent collisions between two or more vessels. Collision Rules include a set of thirty-eight rules and four annexes.

It was alarming that Syms in his research found that nearly 50 percent of the participants state that in their view the COLREGs problems were caused by ignorance and wilful disregard of the Rules [3]. The international project Avoiding Collisions at Sea (ACTS) is developing an online course that could help learning and understanding the Rules. In order to reduce the number of collisions at sea and ensure safer navigation, it is important for the seafarers to thoroughly understand the COLREG and its application. The new COLREGs module for e-learning includes a Questionnaire [6], the aim of which is to check the understanding of the Rules and the manner of their implementation by different groups of users.

The purpose of this research was to identify misunderstandings of the Rules by students. It was conducted among high school students who have no navigation experience but have acquired some knowledge of the Rules in the subject of Manoeuvring and Regulations for Preventing Collisions at Sea. The authors used the Questionnaire to evaluate the extent of their knowledge of the Rules.

The questionnaire has been designed for two target groups – maritime professional seafarers and non-professionals (amateurs)[6]. It is implicit that the participant should be able to understand the questions. There are four groups of questions. The introductory section contains some general questions for identifying the target group of participants. The central part of the questionnaire contains questions for testing the level of understanding and the degree of correct application of COLREGs, as well as questions for checking the opinion and actions of seafarers in practice. The last group of questions in the questionnaire is intended for teachers and lecturers at maritime colleges. These questions aim to evaluate their maritime experience and understanding of the Rules, but also the methods they use in teaching students.

2 Method

Students of the fourth grade of secondary maritime school acquire knowledge of Regulations for Preventing Collisions at Sea through the subject *Manoeuvring and Regulations for Preventing Collisions at Sea*. According to the curriculum, the students will acquire basic knowl-

edge of ship manoeuvring and application of regulations for preventing collisions through the course of 64 hours, out of which 43 are lectures, 3 practical work, 7 revision, 10 knowledge assessment and 1 hour is for evaluation of knowledge. Teaching methods and methodological forms of work in classes are: frontal, individual and group work. Teaching resources and aids prevalent during classes are textbooks, a computer program called PISM, a projector, a computer with internet access, a board and a chalk, a simulator and a checklist. For successful mastering of Manoeuvring and Regulations for Preventing Collisions program, the following foreknowledge is necessary: Maritime Law, Physics, Maritime Communications, Basic ship theory, Safety at Sea, Terrestrial Navigation and Meteorology. Classes take place in a specialized classroom and IT room.

In the Maritime School all the Nautical Studies students have been tested. The questionnaire was conducted on a sample of 27 fourth-grade students of secondary maritime school, consisting of 26 male students and 1 female student, age range 17-19. All students are Croatian nationals and have completed their primary education in Croatia. It is determined that the students do not have any maritime experience. These students were contacted in person and a sample of 27 correctly filled in questionnaires was collected, representing a rate of return of 100 percent.

When it comes to the type of questions in the questionnaire, they are closed-ended questions, which means that the answers are offered in a predetermined form and provide the participant with a number of responses they can choose from. Open-ended questions are the other type of questions found in the questionnaire.

The analysis is based on the questionnaires completed by students of secondary maritime school. Based on the results of the questionnaire, the authors have calculated the frequencies and percentages relating to the understanding and application of the 19 Rules, 14 of which were used to assess the students' knowledge. Through the questionnaire, the authors collected data, information, views and opinions on the subject of the research. The results of the empirical analysis were processed by employing appropriate mathematical and statistical methods in order to analyse and compare them to other research results.

Although the questionnaire was conducted on a rather small sample of participants, an insight into understanding of the Regulations was nevertheless obtained. Furthermore, the questionnaire investigated the participants' opinions on the best way of learning and included a self-assessment of their understanding of the Rules.

The central part of the questionnaire was grouped into two parts containing questions for:

– Checking the level of understanding and the degree of application of the Rules,
– Determining the students' opinion and actions in described real life situations.

The questionnaire contains open-ended and closed-ended questions. Closed-ended questions offer predefined responses and the participants task is to opt for one of the answers. Open-ended questions provide complete freedom to participants in shaping their response.

3 Results

The research was carried out on students of secondary maritime school in order to determine their level of understanding of COLREGs. The results were analysed separately for each participant, and afterwards they were summed up to obtain the overall results. The research results essential for the purpose of this paper are shown and explained in the following sections.

3.1 Checking the level of understanding and degree of application of COLREGs

The conducted questionnaire contains a full range of closed-ended questions intended to check the level of understanding and degree of application of the Rules. The goal is to find out which Rules are more difficult to understand and which are the most likely to be violated in practice. There are 35 questions based on the content of 14 Rules. The percentage of correct and incorrect answers is shown in the Table 1. The participant answers by choosing one of the predefined responses.

Table 1 The percentage of correct answers

Rule number	Correct answers (%)
1	63
3	59
5	96
6	44
7	81
8	93
9	48
10	63
13	26
14	67
15	70
17	41
18	33
19	48
Average percentage	**59**

Source: Authors

The results show that students are able to correctly interpret 59 percent of Rules, while 41 percent of Rules were interpreted incorrectly. The highest percentage of correct answers relates to Rule 5, the Look-out. The percentage of correct answers to questions regarding this Rule is 96 percent. The least number of correct answers was provided for Rule 13, Overtaking. Only 26 percent of students responded correctly to this question.

3.2 Determining the students' opinion regarding individual rules

Questions asked in order to explore the opinions are both open-ended and closed-ended. The analysis of research results is presented in the following subsections.

3.2.1 Safe passing distance, distance between vessels appropriate for initiating actions to avoid collision

Regulations for Preventing Collisions at Sea do not cover all possible situations that may occur in real-life situations [1]. Due to the increasing traffic density, vessels encounter at a lesser distance and there is little time and space for a suitable collision avoidance manoeuvre [4]. The Rules do not specify a response to questions about passing at a safe distance nor the exact distance between two vessels appropriate for initiation actions to avoid a collision. Questions about these issues in the questionnaire are open-ended. Answers are shown in the charts below (Figure 1 and Figure 2).

Chart in Figure 1 shows that 33 percent of students think safe passing distance between two vessels is 1 M, while 56 percent believe that it should be more than 1 M for the scenario described in question.

Appropriate distance for initiating actions to avoid collisions in students opinion is shown by the chart in Figure 2. It is evident that in the described scenario, only 30 percent of students would initiate actions to avoid a collision at a distance greater than 5 M, while 51 percent of them would initiate actions to avoid collision at a distance of 2 M or less.

3.2.2 Checking opinions – predefined responses

This section examines the attitude of students in specific situations and provides predefined responses as follows:

1. Close-quarter situation is defined as:

– The minimum distance between vessels where the collision can still be avoided by one vessel manoeuvring – 22 percent,

– The minimum distance between vessels where the collision can still be avoided by both vessels manoeuvring – 52 percent,

– The minimum distance between vessels where the collision can still be avoided by one vessel manoeuvring, and that such action will result in the vessels passing at a safe distance – 26 percent.

2. In the questionnaire the scenario was described in textual and graphic forms: Vessels A and B are sailing on parallel courses at a distance of 5 miles. The speed of vessel A is greater than speed of vessel B. When they are abeam, vessel A alters her course to port and a risk of collision exists.

The students were asked to name the rule which applies in such situation. Below are the offered responses, the results being indicated after each response.

– Rule 13 (Overtaking), vessel A shall keep out of the way of vessel B – 26 percent,

– Rule 15 (Crossing situation), because vessel A is on the starboard side of vessel B – 63 percent,

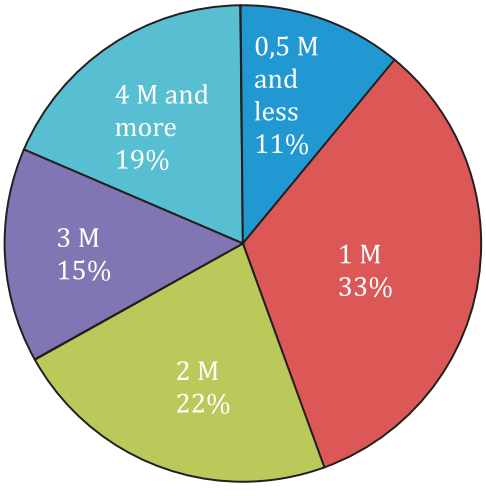

Figure 1 Safe passing distance

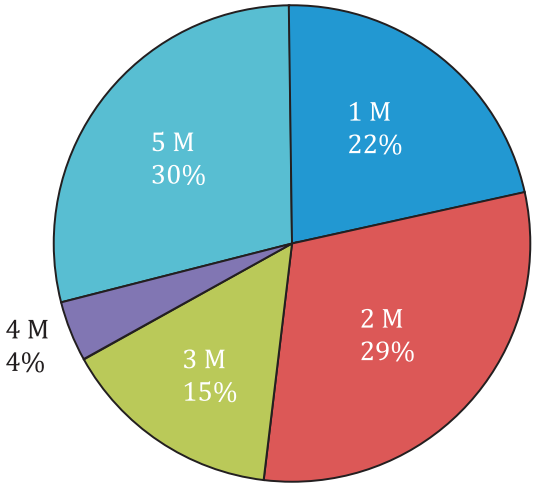

Figure 2 Appropriate distance for initiating actions to avoid collision

Source: Authors

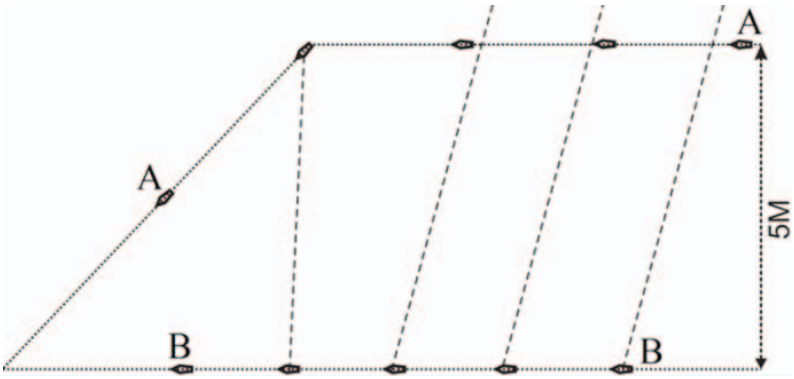

Figure 3 Parallel courses, different speed, altering courses

Source: http://limesurvey.c4ff.co.uk/index.php?r=survey/index

Figure 4 Crossing situation

Source: http://limesurvey.c4ff.co.uk/index.php?r=survey/index

– In such a case it is not possible to determine which rule shall apply, therefore vessels should contact each other using VHF and agree for appropriate manoeuvre – 11 percent.

3. In order to find out opinions and actions of participants in real-life situations, the questionnaire describes a situation where two vessels are meeting in a crossing situation. Vessel A which is the give-way vessel is not taking appropriate action. In this case vessel B, the stand-on vessel, takes action to avoid collision with vessel A. The question is, when would the participant on vessel B take action to avoid collision?

The possible responses for manoeuvring of vessel B in this case are:

– When the distance between vessels is reduced to 1 M – 7 percent,
– 5 minutes after the stand-on vessel determines that the risk of collision exists (CPA = 0) and that the give-way vessel A is not taking any action – 15 percent,
– At the distance, which is smaller than the normal distance at which give-way vessel should take action to avoid collision, but is still great enough to avoid collision – 30 percent,
– Immediately after vessel B gives the warning signal and vessel A does not take any action – 48 percent.

4. Rule 2 (Responsibility) states that nothing in these rules shall exonerate the master or crew (OOW) from the consequences of any neglect to comply with any of these rules which may be required by the "ordinary practice of seamen" or required by the special circumstances of the case. Three definitions of meaning of the term "ordinary practice of seamen" are provided:

– Actions taken by the master and officer who have gained experience while sailing on vessels – 52 percent,
– Actions taken by all seamen who gained education in compliance with STCW convention – 33 percent,
– Actions which can be expected from ordinary (average) master or officer – 15 percent.

3.2.3 Self-assessment of understanding

The goal was to identify the gap in understanding the Rules. Students were required to carry out self-assessment of understanding Rules 1 to 19, marking the Rules that they found more difficult to understand. Figure 5 displays the percentage of rules students believe they can understand.

The conclusion is that most of the students think they understand more than 80 percent of the Rules. Seven students even consider they have a thorough understanding of all of them.

The study also required the students to specify which specific Rules they believe they do or do not understand. The results are shown in Figure 6.

Based on the results in Figure 6 it can be concluded that students estimate Rule 1 (Application), Rule 2 (Responsibility), Rule 4 (Application), Rule 8 (Action to avoid collision) and Rule 13 (Overtaking) are completely understandable. The students consider they have the lowest level of understanding Rules 16 (Action by give-way vessel), 17 (Action by stand-on vessel), 18 (Responsibilities between vessels) and 19 (Conduct of vessels in restricted visibility).

A correlation analysis was performed to measure the link between variables in order to examine compliance between students' actual knowledge and their assumptions about how well they actually understand the Rules. The average values of actual knowledge and estimation of knowledge are given in median, and the variations in quartiles. On average, the students have achieved 16 points out of a maximum of 31, in which the first quartile was 15 and the third 18. The values of estimation of knowledge were much higher. On average, the students estimated their work on the knowledge test Me = 29, in which the first quartile amounted to 27 and the third to 31. The difference between the average value of the actual performance in the knowledge test and the estimation of the performance in the knowledge test was tested by the Wilcoxon signed rank test, which is $Z = 4.55$, $p < 0.001$. All students estimated that they would achieve a better performance than they actually did. When the results achieved in knowledge test are subtracted from the estimated knowl-

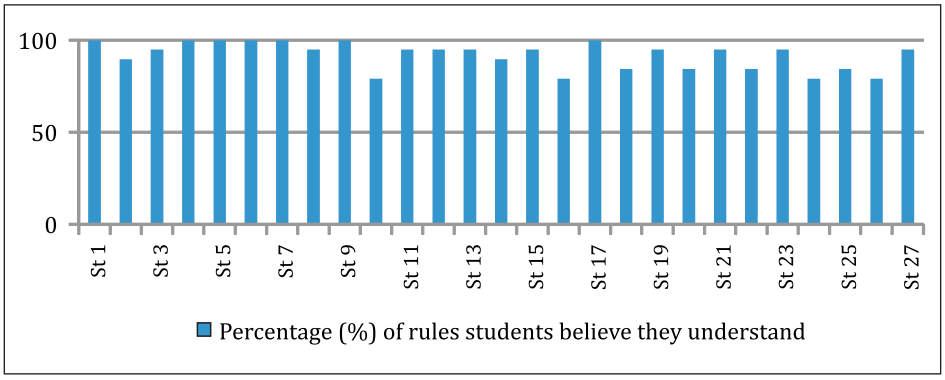

Figure 5 Self-assessment of understanding (Rules 1-19), the percentage of rules students believe they understand

Source: Authors

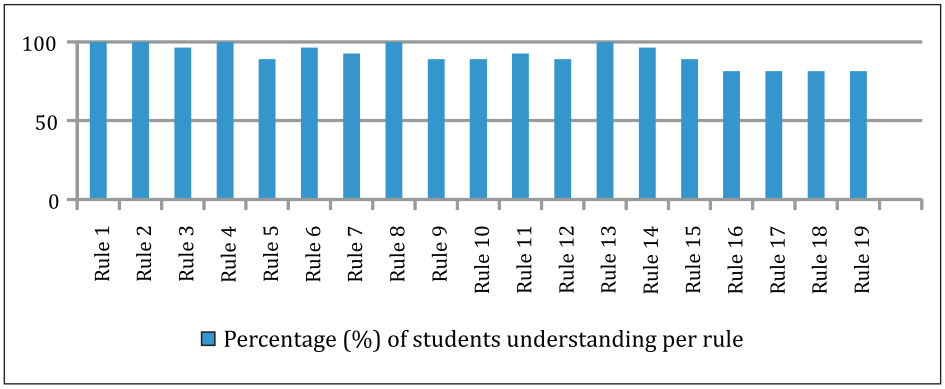

Figure 6 Self-assessment of understanding each Rule (Rules 1-19)

Source: Authors

edge, it can be concluded that the students overestimated their knowledge by 12 points on average, the first quartile amounting to 10 and the third to 15.

Finally, the Kendall tau correlation coefficient is -0.35, $p < 0.05$. In other words, there is a statistically significant negative correlation between actual knowledge and estimation. Therefore, students who overestimate their knowledge achieve poorer results in tests of knowledge.

3.2.4 Students opinion on effectiveness of learning methods

Tot [5] believes that with new techniques, methods and procedures for knowledge acquisition there is an increase in need for developing a new structural arrangement of teaching content. The rules can be learned by using different learning methods, and the goal was to try and determine which method the students believe is the most effective. The closed-ended questions employ a series of seven intensities, whereby one means the least effective, while seven is the most effective method. The following contentions were provided:

- Classroom teaching with teacher explaining each rule,
- Using self e-learning (self-study, self-improvement learning with computers),
- Learning COLREGs using navigational simulator,
- Learning COLREGs using real-life or prepared scenarios e.g. animations,
- Online learning in a group (incorporates computer, web-based and e-learning),
- Distance learning – in a group (interaction with instructor and students through PCs from a distance),
- Practical training on board.

Results and an answer to the question of which method of learning the students favour were obtained by calculating the mean value. Evaluation was carried out in a scale of one to seven and the results are shown in Figure 7.

The learning methods that the students considered to be the most effective are: Practical training on board with an average score of 5.59, Learning the rules by using navigational simulator with an average score of 5.48, and Learning the rules by using real-life or prepared scenarios (eg, animations) with an average score of 5.07. The students have evaluated method of Classroom teaching with teacher explaining each rule with an average score of 4.48.

Methods the students believe are the least efficient are: Using self e-learning (self-study, self-improvement type with computers) with an average grade of 2.44, Online learning in a group (incorporates computer, web-based and e-learning) with an average score of 2.44 and Distance learning in a group (interaction with instructor and students through PCs from a distance) with an average score of 2.67.

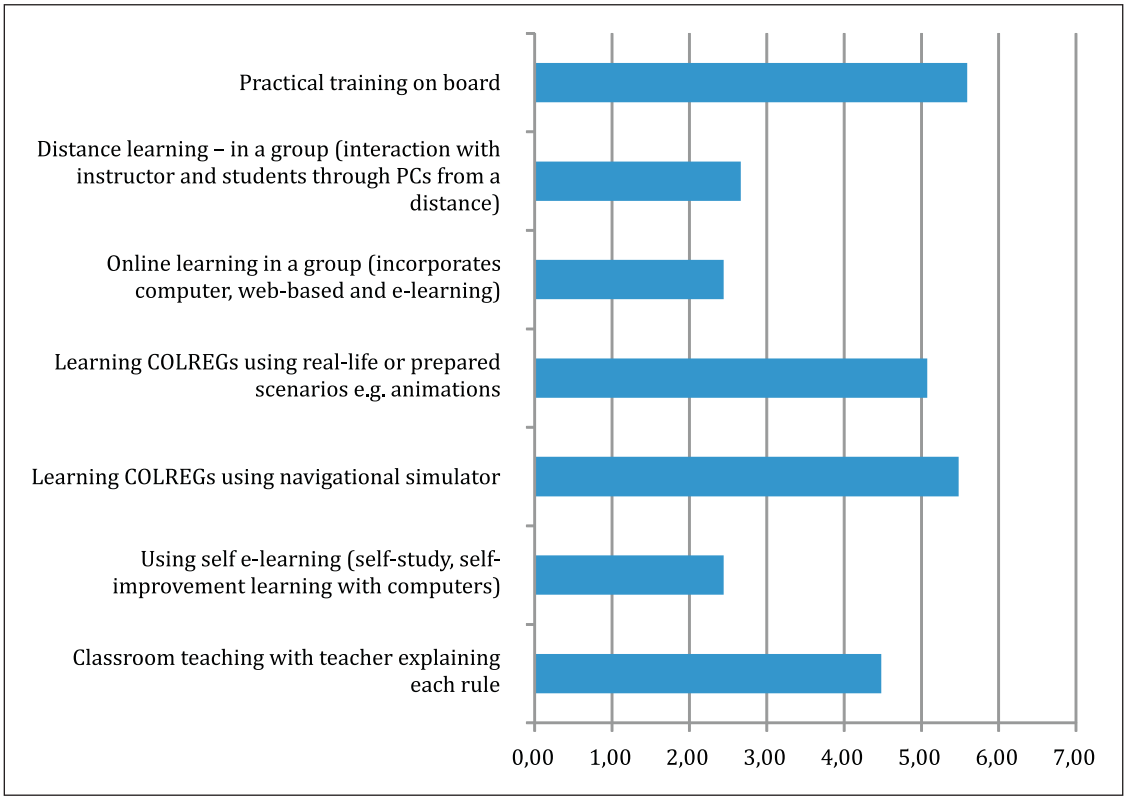

Figure 7 Choosing the most effective learning method

Source: Authors

4 Discussion

The empirical results are similar to the results provided in the introductory section of the paper where it was stated that almost 50 percent of seafarers disregard/ignore COLREGs at sea. Namely, the results of the study indicate 41 percent of students would in real-life situations ignore or incorrectly apply the Rules.

The same questionnaire was carried out in school year 2013/2014 on a sample of 50 participants within the same age group. The research results show that students correctly interpret 55 percent of Rules, while 45 percent of Rules are interpreted incorrectly. When comparing the data from both studies, it can be noted that the results show a similar tendency.

The students' subjective self-assessment of their understanding of the Rules is inconsistent with the results obtained during the test of their knowledge. Objective indicators show that the students correctly interpret 59 percent of the Rules. There is also evidence that students have a wrong perception of the level of their knowledge.

As the most effective methods of teaching students suggest practical training on board, learning on the simulator and learning with animations. The question of the most effective methods of learning should be viewed from a more fundamental aspect because very few classes are dedicated to precisely these methods. Students have very little or no experience with learning through these methods. Taking these facts into account, it can be concluded that a high need for implementation of such content into the curriculum exists.

However, students have not forgotten the importance of classroom teaching with the explanation and commentary of every rule. It is important to emphasize the need for balanced application of traditional and new teaching methods.

The goal of modern teaching strategies is to prepare and train the students in self-learning, self-study, i.e. continuous education and creativity through active interaction and communication between teachers and students [2]. Different teaching methods make teaching more stimulating for students and teachers since more learning methods ensure better performance and adequate learning of teaching content.

Of course, this study has its disadvantages which are primarily found in the limitations set in the Questionnaire. This limitation stems from the fact that the questionnaire does not offer "Do Not Know" option. By including "Do Not Know" in the questionnaire, the participants are given the possibility not to choose any of the answers available. This type of response provides significant insight into the knowledge of participants, as well as their ability to answer the question. "Do Not Know" is a legitimate response to many questions the participant really does not know how to answer.

5 Conclusion

To improve the safety of navigation, it is of utmost importance to thoroughly understand the Rules. COLREG questionnaire was designed to determine the participants' understanding of the application of rules. Results may serve lecturers and teachers in maritime colleges and schools to improve classes by focusing their efforts on the Rules which the students do not understand completely.

The analysis of the Questionnaire showed that the students do not fully understand the Rules. The results of this research show similar tendency with the results gathered in previous years from the same group of participants.

One should take into account the fact that students do not have navigation experience and their knowledge is mostly theoretical. Accordingly, it is necessary to enable students to use multiple methods of learning such as e-learning, learning by using navigation simulator, learning by using real-life or prepared scenarios, online learning in a group and distance learning in a group. In addition, it is necessary to sensitize teachers in the education of seafarers on the use of information technologies in teaching.

Because of the importance of the problem of this study, it is necessary to continue the research and evolve it in the direction of setting up the following hypothesis: the best results are obtained by students who are taught in a way that suits their learning style. There is a growing need for more effective, meaning more accurate and timely, education, which will also be open and widely available. For the students to adopt more knowledge during the learning process, it is necessary to explore new ways of individual knowledge acquisition.

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