On diagnosing the level of students’ knowledge in special (conventional) disciplines

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Abstract. One of the most important tasks of professional training of cadets at maritime universities is to prepare them for competent actions in any accident and emergency. The International Maritime Organization (IMO) reiterates the importance of naval professional training. IMO normative acts like conventions, codes and resolutions indicate that each crew member should be able to maintain the required safety, objectively assess current conditions, navigate in a difficult situation, prevent an accident from developing into an emergency, correctly apply fire extinguishing equipment, quickly close holes, remove accumulated water that threatens ship stability, etc. Implementation of IMO requirements is the main direction in studying special and conventional academic disciplines. For quality assurance of cadets’ learning achievements in the overall academic discipline, it is advisable to use diagnostic assessments. The paper is geared to investigate the way students develop their professional competency when they master special (conventional) disciplines through education diagnostic assessments. The paper aims to develop a toolkit for providing a reliable assessment of the level of mastery of the academic discipline on Basic Security Training by cadets. The authors creatively applied the method of theoretical analysis of scientific literature; testing method; forecasting method; methods of mathematical verification of the reliability and validity of the developed test. In the end, a new test to assess the level of cadets’ performance in a special (conventional) discipline is a correct and timely action. The developed test will replenish a critical pool of diagnostic education resources and will be in demand for education diagnostic assessments in modern maritime education institutions.

1 Introduction

Professional activity of transport seafarers is one of the most tiring and challenging, because the process of navigation involves risks to life and health of ship’s company [1].

One of the commandments of maritime professional activity says that every seafarer, while at sea, should be prepared for any situation and be able, in extreme cases, to survive and save lives [2]. The most essential IMO documents, the International Conventions SOLAS-74/78 (2021) [3] and STCW-78 as amended (2010) [4], require each seafarer to be theoretically and practically ready to act competently in any emergency, be able to save themselves and save other crew members in an emergency.

The topic is relevant due to:

• high social and national demands for professional competency of graduates of maritime universities;
• the need for graduates to meet the emerging competitiveness in the labor market;
• growing requirements of the International Maritime Organization and employers for trained crew members, their willingness and ability to withstand any emergency, extreme and emergency situations;
• high requirements of the state set forth in the Federal Law On Education in the Russian Federation (2012) to the level and quality of professional training provided in higher education institutions;
• the need for interim and final assessments to measure the level of students’ knowledge in special (conventional) disciplines by using education diagnostic tools.
• Various aspects of organizing and providing education diagnostic assessments were considered by such scientists as A.S. Belkin, A.I. Kochetov, N.K. Golubev, V.P. Bispalko, B.P. Bitinas and L.I. Kataeva, V.G. Maksimov, O.Yu. Efremov and others.

Hence, the topic of education diagnostic assessment to measure students’ performance, both in mastering systematic topics within academic disciplines, and during final assessment, is relevant and timely.

2 Materials and Methods

The paper aims to design a new education test to reliably assess the level of mastering a special
(conventional) academic discipline by students and conduct statistical tests of its validity, reliability, and performance.

The paper is aimed at professional training of students in the special (conventional) discipline on Basic Security Training.

The paper investigates the way students develop their professional competency when they master special (conventional) disciplines through education diagnostic assessments.

The paper hypothesizes that professional competency in the study of special (conventional) academic disciplines at a university using education diagnostic assessment will be productive if the following conditions are met:

- the idea and content of education diagnostic assessment are defined;
- the term “education test” is clarified;
- a test is developed and piloted to check the level of students’ achievements in the special (conventional) discipline on Basic Security Training to assess survival knowledge, including the importance of training and drills.

In accordance with the goal and hypothesis, the following research objectives were defined to:
1. Make a theoretical analysis of scientific literature on the topic.
2. Clarify the concepts of “diagnostic assessment”, “education diagnostic assessment”, “education test”.
3. Define the functions of education diagnostic assessment.
4. Find out the features of education testing.
5. Develop a test on Assessing Survival Knowledge Including the Importance of Training and Drills.
6. Organize final assessment and pilot the developed test.
7. Provide statistical validation of the developed test.

To meet the objectives set and achieve the goal intended, the authors creatively applied a set of methods including theoretical analysis of scientific literature; summarizing the experience of scientists and researchers in the field of pedagogical testing; testing method; forecasting method; methods of mathematical verification of the reliability and validity of the developed test.

The paper will rely on the following terms:
- **diagnostic assessment** – a way of learning, studying and establishing various relationships, states, qualities and properties of objects of study;
- **education diagnostic assessments** – activities to identify the current state and trends in personal development, educational agents interacting to improve the quality of learning process;
- **education test** – a pool of tasks of a specific form, a certain content, increasing difficulty, designed to provide objective assessments of the content and qualitatively measure the level of students' performance;
- **testing** is a form of measuring students’ knowledge based on the use of education tests [7].

Testing is geared to perform the following main functions: **diagnostic** (consists in identifying the level of students’ knowledge, skills, abilities), academic and educational (implies regular assessments to discipline students, streamline learning activities, detect, and fill the lacuna in knowledge) [7].

## 3 Results and Discussion

The academic discipline on Basic Security Training is designed to prepare cadets studying at maritime universities for future professional activities on board ships, competent actions in emergency, accidents and extreme situations, and survival at sea.

The term “survival” implies a set of actions that people can use in dangerous situations to save their lives and others.

Maritime practice confirms that the probability of rescuing seafarers in distress is quite high. However, a lot depends on the shipwrecked themselves, their mood and efficacy for self-rescue, overcoming fear.

Surviving and living in a life-saving facility (lifeboat or life raft) require from seafarers’ high discipline, following the principle of one-man command, complete trust in each other, maintaining cheerfulness and firm conviction in overcoming all difficulties.

It is crucial for every sailor to know survival rules including the importance of training and drills being the backbone of knowledge, skills and abilities developed [6].

To measure the level of cadets’ survival knowledge including the importance of training and drills, an appropriate methodology was developed containing a test questionnaire (Table 1). The test questionnaire was developed based on the recommendations of S.I. Kondratiev and co-authors [1, 2].

### Table 1. Contents of the Survival Test Questionnaire, including the Meaning of Training and Drills.

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<th>No.</th>
<th>Multiple choice questions</th>
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| 1.  | Survival principles include:  
|     | a) the importance of training and drills; personal protective clothing and equipment; the need to be prepared for any accident; actions to be taken when commanded to proceed to the location of lifeboats and rafts;  
|     | b) actions to be taken when abandoning a ship; actions to be taken while in the water; actions to be taken while on a lifeboat and raft;  
|     | c) major life-threatening dangers to survivors. |        |
2. SOLAS-74 requires drills (dinghy and fire fighting) on passenger ships:
   a) daily, for the first two weeks;
   b) weekly;
   c) monthly.

3. Passengers on passenger ships muster for training purposes no later than:
   a) within 4 hours of the vessel leaving a port;
   b) within 12 hours of the vessel leaving a port;
   c) within 24 hours of the vessel leaving a port.

4. On cargo ships, drills are held at least:
   a) once a day during the first week;
   b) once a week;
   c) once a month.

5. When a ship has a crew change of 25 percent and over what is the time limit that a security drill be conducted on board:
   a) within 12 hours after the vessel embarks on a voyage;
   b) 24 hours after the vessel embarks on a voyage;
   c) 36 hours after the vessel embarks on a voyage.

6. During dinghy drills, different kinds of dinghies are used alternately, with each dinghy to be launched and, as far as practicable, lowered to the water:
   a) once a month;
   b) every three months;
   c) every four months.

7. Crew’s emergency preparedness should be controlled by:
   a) the captain of the vessel;
   b) harbor master’s service;
   c) shipowner’s service.

8. Ship’s crew emergency preparedness can be checked by the relevant services in a foreign port based on:
   a) Harbor Master’s order;
   b) information on inadequate crew preparedness to act in accidents and emergency situations;
   c) international regional agreements (Paris Memorandum, Tokyo Memorandum, etc.).

9. The forms of crew emergency preparedness are:
   a) theoretical and practical classes;
   b) rescue operations;
   c) peripheral and public drills.

10. General ship drills are conducted with the entire crew of the vessel under the direct supervision of:
    a) the captain of the vessel;
    b) captain-instructor;
    c) executive officer or a responsible safety officer.

11. Upon arrival on the ship, each crew member should be trained and briefed no later than:
    a) within five days; b) within two weeks; c) within a month.

12. Safety briefings of newly arrived crew members should include the following questions:
    a) activation and use of the ship’s inflatable operational means;
    b) use of ship’s life-saving equipment in harsh weather and rough seas;
    c) hypothermia, first aid for hypothermia and other cases.

13. On a monthly basis, each crew member on board a ship shall participate in at least:
    a) one abandon ship drill and one fire fight drill;
    b) two abandon ship drills and one fire fighting drill;
    c) one abandon ship drill and two fire-fighting drills.

14. An abandon ship drill should include the following:
    a) notification of the crew and passengers to muster in the assigned station by means of the vessel’s general announcement system that gives clear instruction to follow for abandoning the ship in accordance with the muster list; mustering in the assigned station and getting ready for requirements on the muster list; making sure that all crew members and passengers have put the personal life jacket on;
    b) making sure that life jackets are properly worn; preparation for the launch of the lifeboat and its lowering; start-up and operation of the lifeboat engine;
    c) search and rescue of dummies blocked in cabins; briefings on the use of radio equipment for life-saving means.

15. Each lifeboat with the operating crew on board and each rescue boat must be launched and maneuvered in the water during an abandon ship
In the beginning, the quality of test assignments was evaluated, including a statistical assessment of separate test questions and the entire test using Microsoft Excel.

The quality assurance of the test-questionnaire was modelled based on the findings and included: calculation of individual scores of each respondent; the number of correct answers $R_i$ for the $j$-th question of the test-questionnaire ($j = 1, 2...20$); the number of incorrect answers $W_j$ to the $j$-th question of the test-questionnaire ($W_j = N - R_i$); proportion of correct answers $p_j (p_j = \frac{R_j}{N})$; proportion of incorrect answers $q_j (q_j = 1 - p_j)$; variation (dispersion) of test scores $p_j \cdot q_j$ for the $j$-th question of the test-questionnaire; standard deviation of examinee results for the $j$-th question; determination of the arithmetic mean $\overline{x} = \frac{1}{N} \sum_{j=1}^{N} x_j = 11.6$; calculation of variance $s_x^2 = \frac{1}{N-1} \sum_{j=1}^{N} (x_j - \overline{x})^2 = 10.3$ and standard deviation $S_x = \sqrt{s_x^2} = 3.2$.

The objective nature of the test questions as instrumentation confirming the effectiveness of the chosen methodology to achieve the goal of determining the level of survival knowledge, including the importance of training and drills, was assessed against such basic requirements as reliability, validity, and discriminatory power.

The reliability of the test-questionnaire implies the consistency of test results when redone under different modified conditions (in different time and with other questions comparable in concept). This type of reliability is called test-retest reliability. For this, various correlation coefficients were calculated for initial and repeated testing, confirming the effectiveness of the technique applied. Apart from the test-retest reliability, one of the reliability criteria is the criterion related to the content and internal consistency of test assignments (self-consistent). To do this, a method was used for splitting the test into two equivalent parts and assessing the effect of splitting the test, calculating the reliability coefficient using the Spearman-Brown prediction formula (1):

$$ r_n = \frac{\pi r_{ij}}{1+(\pi-1)r_{ij}}, $$

where: $r_n$ is the expected value of the safety factor; $r_{ij}$ is the average cross-correlation between tasks; $n$ is the number of tasks.

One of the criteria for evaluating the test-questionnaire is discriminatory power related to the ranking of respondents. This approach relies on the analysis of the results from individual test questions, if possible, to differentiate cadets against the “maximum” or “minimum” result of the test-questionnaire. Since this test uses a dichotomous scale, when 1 point is given if

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Table 2. Answers to the Survival Test Questionnaire, including the Meaning of Training and Drills test.

At the next stage of the study, the results of the methodology applied were statistically processed.
the answer to the question is correct, or 0 if the answer is incorrect or incomplete, then the sum of points for all questions represents the primary assessment of each respondent. In this case, the measure of the discriminatory power of a test question across the entire sample of test takers is a measure of the consistency of a successful answer to the question posed to the score on the entire test questionnaire and is determined using a biserial correlation coefficient or discrimination coefficient according to the formula (2):

$$r = \frac{\bar{x}_{1j} - \bar{x}_{0j}}{S_x} \sqrt{n(n-1)}$$

where $\bar{x}_{1j}$ is the average individual score of the respondent who answered the $j$-th task correctly; $\bar{x}_{0j}$ – the average individual score of the respondent who answered the $j$-th task incorrectly (incompletely); $n_{1j}$ is the number of respondents who answered the $j$-th task correctly; $n_{0j}$ is the number of respondents who answered the $j$-th task incorrectly (incompletely); $n$ is the total number of respondents; $S_x$ – standard deviation of individual scores of all respondents.

The coefficient of discriminatory power of the test-questionnaire questions also indicates criterion validity of individual questions since it is calculated against the total score. The resulting correlation coefficients exceeding 0.5 confirm the validity of the test questions.

4 Conclusion

The final assessment confirms that the test questionnaire developed by the group of authors is objective and high-quality, reliable, and valid. The assertion is grounded on its scientific rationale, experimental verification through several criteria. Once applied, it objectively evaluates the true level of cadets’ knowledge required for survival at sea.

The methodology can be leveraged to provide conventional training opportunities for maritime students, to improve the quality and effectiveness of mastering the curriculum.

The usefulness of the technique is indisputable, obvious, and confirmed by the findings provided by the staff at the Admiral Ushakov Maritime State University.

References

6. A.N. Tomilin, S.I. Pankina, S.N. Tomilina, A.M. Dorofeev, E.M. Dorofeev, To the question of understanding the essence of the human factor by the ship's crew members and their predisposition to create an emergency situation, Operation of Marine Transport 2(103), 50–56 (2022)