Practical application of pedagogical diagnostics to assess cadets' knowledge of lifeboat and raft equipment

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Abstract. An essential component of the professional training of maritime cadets is their readiness to act skilfully in any accident or emergency situation. When a ship is destroyed, it is the responsibility of every crew member to know how to use the salvage equipment available on board and how to use it promptly and effectively. The subject of the study is the professional training of maritime cadets. The authors of the article substantiate and disclose the main points of the methodology for assessing the knowledge of lifeboat and raft equipment of maritime cadets. The methodology aims to serve in the convention training process as well as in the final certification of cadets in the Initial Security Training discipline. The article contains the results of the experimental work: testing cadets on the test-questionnaire of the considered method, their analysis and interpretation, as well as the mathematical processing of the results, proving the reliability and validity of this method. The authors agree that the use of the developed methodology in the practice of convention training in all maritime educational organisations would be appropriate and effective.

1 Introduction

The topics of the Initial Safety Training syllabus include an in-depth study of lifeboat and raft equipment. Practice shows that many second-year students confuse the terms “equipment” and “construction”, often mixing them up.

A review of the scientific literature relating to shipboard lifesaving equipment has shown that there is no explanation of the term “lifesaving equipment”.

To define the essence of the term “equipment” we conducted a content analysis of the reference literature [6, 8], the results of which are summarised in Table 1. Analysis of Table 1 suggests that the term “equipment” should be understood to mean a set of devices, appliances, instruments, tools designed to perform a function or action, to achieve a goal.

To gain a deeper understanding of the essence of the term “equipment”, we examine the contents of training manuals intended for the professional training of future maritime transport professionals, the convention training of cadets in the disciplines “Initial Safety Training” and “Lifeboat and Raft and Duty Lifeboat Specialist Training for Non-Speed Dinghies.”

Thus, in the textbook “Ship Theory and Design” developed by V.V. Scherbatykh [7] there is an author's definition of the term “rescue equipment” explained as a complex of means for rescuing people from a sinking vessel or in case they fall overboard. It includes lifebuoys and equipment for installing them, securing them to the vessel and launching them into the water. It can be used collectively (dinghies, rafts, lifebuoys) or individually (lifebuoys, bibs, waistcoats).

However, as we can see, it is very broad and generalised and does not specifically explain the meaning of lifeboat and lifeboat duty equipment and rafts.

Each ship’s liferaft (lifeboat, lifeboat on duty, life raft) has its own equipment. There are two ways of referring to this: firstly, the generic term “shipboard equipment of lifebuoys”; Secondly, on the equipment of a particular ship's liferaft - rescue boats, lifeboats on duty, life rafts.

It may refer to two options: firstly, to the generic term “marine life saving equipment;” secondly, to the equipment of a specific marine life saving equipment – “equipment of ship's lifesaving vehicles” – rescue boats, duty boats, life rafts.

The International Convention SOLAS-74/78 as amended [4] and the LSA Code [3] contain a mandatory list of equipment for every shipboard liferaft. For example, here is a list of equipment for the lifeboats of marine transport vessels.

Thus, all lifeboats shall have the following equipment: a clearly marked and cap-locked release valve (except drop-over dinghies); rudder and tiller; above the waterline a handrail or floating lifeline; handrails at the bottom of the hull to enable people to hold onto the lifeboat; waterproof boxes or compartments for supplies; facilities for rainwater collection and storage; a release mechanism on a single point hanger or on a hoist, to disengage the lifeboat from them (except drop-over dinghy); a bollarding device in the bow of the dinghy for towing by ship at up to 5

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knots, with a bollard release mechanism from inside the dinghy; skids and external gunwale beams for launching on board; an external white light with a minimum duration of 12 hours and an internal light for reading instructions of the same duration (12 hours); each dinghy shall have a circular view from the control station to ensure safe launching and manoeuvring.

In addition, each dinghy shall be equipped

<table>
<thead>
<tr>
<th>Table 1. Results of a content analysis of the term “equipment.”</th>
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<tbody>
<tr>
<td><strong>Source</strong></td>
</tr>
<tr>
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<tr>
<td>GOST R IEC 602204-1-2007: Machine safety. Electrical equipment for machines and mechanisms.</td>
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<tr>
<td>GOST R IEC 60204.1-99: Machine safety. Electrical equipment for machines and mechanisms.</td>
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<tr>
<td>RB 91-2000: Requirements for the content of the report on the state of radiation safety at radiation-hazardous objects of the national economy</td>
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<tr>
<td>The Encyclopaedia of Business</td>
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</tbody>
</table>

with a compression-ignition internal combustion engine (ICE) able to the following:

1) start at t=-15°C within 2 min from starting;
2) work for at least 5 min when the dinghy is out of the water;
3) work when the dinghy is filled to the crankshaft axis.

The internal combustion engine must be protected from the weather and exposure to the sea by a non-flammable cover and ensure that persons are protected from burns, mechanical stress and electromagnetic radiation and do not interfere with the operation of the radio equipment.

The internal combustion engine must have a starter (manual or powered by 2 independent rechargeable power sources).

Consequently, the general term “equipment of a ship's rescue equipment” should be understood to mean a set of devices, appliances, instruments designed to equip a ship’s rescue equipment to ensure the necessary equipment, quality performance of certain functions and technical operation, for the purpose of increasing the chances of survival of people in distress on board it.

**2 Materials and Methods**

In accordance with the requirements of International Convention STCW-78 as amended [5], each crew member must receive appropriate pre-voyage training and certification in a number of areas. These include training in the disciplines of Initial Security Training. For this purpose, every seafarer, including every trainee (cadet) should be trained in the following group of issues: Competence: Survival at sea in case of abandonment (Section A-VI/1, Table A-VI/1-1 of the STCW Code). This group of questions also includes those relating to the equipment of lifeboats and rafts.

**3 Results and Discussion**

The diagnostic test-questionnaire contains 20 test questions corresponding to the studied material in the conventional discipline “Initial Security Training.”

The results of the test papers are assessed on a dichotomous scale: 1 point if the answer to the question posed is correct, or 0 if the answer is incorrect or incomplete.

The maximum possible score for all correct answers to the test questionnaire will be 20 points.

The content of the test questionnaire is shown in Table 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Test-questionnaire questions with options</th>
<th>Answer</th>
</tr>
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<tbody>
<tr>
<td>1.</td>
<td>To dry the dinghy after hoisting it is equipped by:</td>
<td></td>
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<tr>
<td></td>
<td>A) sponges and scoops; B) a dewatering pump;</td>
<td></td>
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<tr>
<td></td>
<td>C) automatic opening of the release valve when the dinghy is out of the water.</td>
<td></td>
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<tr>
<td>2.</td>
<td>Each release valve must be:</td>
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<td></td>
<td>A) fitted with a cap or plug to close it, which shall be secured to the lifeboat by a sling, chain or other suitable means;</td>
<td></td>
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<tr>
<td></td>
<td>B) easily accessible from inside the dinghy and their location shall be clearly marked;</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C) made of high strength steel.</td>
<td></td>
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</tbody>
</table>

https://doi.org/10.1051/shsconf/202316400018
3. Every lifeboat shall be equipped with...
   A) a music centre;
   B) a radar station;
   C) a decoupling device that allows the nasal filum to recoil when it is under tension.

4. If the helm fails, the lifeboat is steered with...
   A) oars and a floating anchor;
   B) the tiller;
   C) an engine.

5. Lifeboat and raft supplies can be divided into three categories:
   A) for signalling, draining and repairing the rescue equipment;
   B) for food replenishment and first aid;
   C) for life support, signalling, lifesaving equipment maintenance.

6. All lifeboats shall have...
   A) rudder;
   B) tiller;
   C) motor pump.

7. The rudder of a lifeboat shall be...
   A) made of metal;
   B) right-handed;
   C) permanently attached to the lifeboat.

8. The composition of the lifeboat signalling equipment consists of...
   A) pyrotechnic means;
   B) a signal mirror;
   C) a signal light.

9. What is the composition of the pyrotechnical means of signalling a life raft?
   A) smoke bombs - 2 pcs., false flares - 6 pcs., parachute flares - 4 pcs;
   B) false flares - 4 pcs., smoke bombs - 1 pc., parachute flares - 5 pcs;
   C) parachute flares - 3 pcs., smoke bombs - 1 pc., false flares - 5 pcs.

10. The emergency radio beacon battery is designed to transmit a signal for...
    A) 72 hours;
    B) at least 36 hours;
    C) 48 hours.

11. On which frequency(s) the COSPAS-SARSAT emergency radio beacon operates:
    A) 410.5 MHz and 125.1 MHz;
    B) 425.06 MHz and 124.5 MHz;
    C) 406.025 MHz and 121.5 MHz.

12. How many hours does a radar transponder have to work on standby?
    A) 96 hours;
    B) 48 hours;
    C) 72 hours.

13. What is the range of a radar transponder to be picked up by a ship so that it will mark itself on the radar screen?
    A) 3 miles;
    B) 10 miles;
    C) 5 miles.

14. How will a ship's radar screen indicate a radar transponder at the capture range limit?
    A) in the form of dots (10 to 20 pieces) on the same line;
    B) as a bright round spot;
    C) as a bright triangle.

15. Every lifeboat shall be equipped with
    A) a petrol engine;
    B) a compression-ignition internal combustion engine;
    C) by an engine running on fuel with a flashpoint of 43°C or lower (when tested in a closed crucible).

16. The lifeboat shall be fitted with a light bulb with a manual switch. The light shall be white, with an intensity of not less than 4.3 cd in all directions of the upper hemisphere and with a duration of constant action of not less than
    A) 8 h;
    B) 10 h;
    C) 12 h.

17. Lifeboats lowered on hoists shall be fitted with a release mechanism which is designed so that both hooks are released simultaneously. In doing so, the disengagement mechanism provides for the following means of disengagement:
    A) normal - disconnection takes place after the dinghy has been launched, when the load on the nuts disappears;
    B) under load - where disconnection can be carried out either on the water or on the weight with the load on the nuts;
    C) combined - used in case of emergency abandonment of a ship.

18. Life rafts shall be equipped with a semi-rigid inclined boarding platform capable of carrying a 100 kg person, or with a boarding ramp, the bottom step of which shall be below the waterline of the empty raft:
    A) by 0.2 metres; B) by 0.4 metres; C) by 0.6 metres.
19. All lifeboats must be equipped with a sufficient number: 
A) watertight boxes; 
B) compartments, for storing small supplies, water and provisions; 
C) tableware.

20. Lifeboats, in accordance with regulation 38 of Chapter 3 of the SOLAS-74 Convention, have the following equipment: 
A) lifelines encircled and securely fastened with sleeves on the inside and outside around the liferaft; 
B) a secure falleen of a length not less than twice the distance from its point of installation to the waterline at the vessel's lowest operational draft, or 15 metres, whichever is greater. 
C) mini-radio station.

The key to the questions in the test questionnaire is given in Table 3.

Table 3. Answers to the test “Lifeboat and raft equipment knowledge assessment.”

<table>
<thead>
<tr>
<th>ANSWERS to the test questions</th>
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The methodology was tested by conducting a controlled experiment with 114 final year cadets and 148 second year cadets, who had studied the entire subject of Initial Security Training during the third semester. A total of 262 cadets took part in the study.

It is important to note that all questions in the test questionnaire are balanced in terms of content: the number of questions for each section of the topic corresponds in percentage terms to the full scope of the topic in the Primary Safety Training discipline being studied.

In solving this problem, the authors selected 20 test questions that allow not only to assess the second-year students’ understanding of the theoretical material, but also to evaluate the ability to apply the acquired knowledge in practice, which is confirmed by the test results of the final-year cadets.

At the initial stage of mathematical and statistical processing of the test questionnaire, the main characteristics of the distribution were calculated and analysed using the “Descriptive statistics” tool included in the “Data Analysis” add-in package of Microsoft Excel: arithmetic mean of the examinees’ individual scores $\bar{X}=10.7$; standard error $m = 0.35$; mode (10); median (11); standard deviation $\sigma = 3.4$; skewness factor $A = 0.14$; kurtosis $E = 0.21$. Based on the data obtained, the authors analysed a histogram of the distribution of individual test takers’ scores and checked the consistency of the theoretical and statistical distribution using Pearson's $\chi^2$ goodness-of-fit test. Since the resulting distribution of respondents' scores is close to normal, this indicates the positive differentiating power of the test-questionnaire.

The second stage of mathematical-statistical processing involved examining the content of the test questions and determining the degree of existing relationships between the items.

The study used Pearson's correlation coefficient, which for dichotomous data is called the “phi” coefficient and is defined according to the formula:

$$\phi_{ij} = \frac{p_{ij} - q_{ij} \cdot q_{ij}}{\sqrt{p_i \cdot q_i \cdot p_j \cdot q_j}}$$

where $p_{ij}$ is proportion of correct answers to question number $i$, $q_{ij}$ is proportion of incorrect answers to question number $i$, $p_{ij}$ is proportion of correct answers to question number $j$, $q_{ij}$ is proportion of incorrect answers to question number $j$, $p_{ij}$ is proportion of correct answers to question numbers $i$ and $j$.

The quality of the developed measurement materials in the form of a test-questionnaire was assessed using methods characterising reliability and validity. One of the methods used in reliability assessment, involving a single test, is the split-half method for even and odd numbered questions.

The reliability coefficient was calculated using Pearson's correlation coefficient formula:

$$r_{rel} = \frac{N \sum_{i=1}^{N} X_i Y_i - \left( \sum_{i=1}^{N} X_i \right) \left( \sum_{i=1}^{N} Y_i \right)}{\sqrt{N \sum_{i=1}^{N} X_i^2 - \left( \sum_{i=1}^{N} X_i \right)^2} \sqrt{N \sum_{i=1}^{N} Y_i^2 - \left( \sum_{i=1}^{N} Y_i \right)^2}}$$

where $X_i$ is the individual score of the $i$-examinee on even numbered questions; $Y_i$ is the individual score of the $i$-examinee on odd numbered questions of the test questionnaire. Reliability estimates were also correlated using the Spearman-Brown formula: $r_{e.rel} = \frac{2r_{rel}}{1+r_{rel}}$. In this study, a coefficient of 0.81 was obtained from the respondents' results, exceeding the permissible lower limit of 0.7.

The validity of individual test questions was assessed by calculating the values of the biserial correlation coefficient using the formula:
The study of the correlation matrix and the calculated point biserial correlation coefficients \(0.49 < r_j < 0.71\) confirm the validity of the test questions.

4 Conclusion

The experimental work allows to assert that the developed methodology is objective and allows to check qualitatively level of knowledge of cadets on questions concerning equipment of ship saving means.

The respondents\’ answers allow us to state that maritime cadets in general are trained in methods of personal survival at sea, have a firm knowledge of shipboard rescue equipment, their purpose, and the logic of actions to use them in an emergency situation.

This methodology can be effectively used in convention training with students of maritime educational organisations, establishing the quality and performance of the Initial Security Training curriculum.

The practical relevance of developing this methodology is indisputable, evident and supported by the results of this study.

References

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