

MET institutions; quality; assessment; fuzzy assessment; CAF 2006

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QUALITY STANDARDS IMPLEMENTATION IN MARITIME EDUCATION AND TRAINING INSTITUTIONS: FUZZY ASSESSMENT

Summary. Efficient organization of maritime industry is based on adequate human resources. Knowledge and skills are the results of a well organized study process and training. Since education is part of the public administration, the European Quality Management tool for the Public Sector - Common Assessment Framework (CAF) could be used, in accordance with the STCW convention requirements as a starting point to develop a model that allows quantitative assessment of the Maritime Education and Training (MET) institutions. Evaluation results and procedures are usually described qualitatively as verbal assessments that are part of a report or are summarized in statistical reports. Fuzzy reasoning permits a transition from qualitative to quantitative decision making. For this purpose, we suggest fuzzy modelling, which gives a quantitative assessment of education effectiveness. Evaluators' verbal assessments could be linguistic input variables of a fuzzy decision model, based on CAF recommendations and STCW convention that produces a quantitative mark of the Maritime Education and Training Institution quality.

STANDARDY REALIZACJI JAKOŚCI W EDUKACJI MORSKIEJ I INSTYTUCJACH SZKOLENIOWYCH: OCENA ROZMYTA

Streszczenie. Wydajna organizacja przemysłu morskiego jest oparta na odpowiednich zasobach ludzkich. Wiedza i umiejętności są rezultatem dobrze zorganizowanego procesu nauczania oraz szkolenia. Od kiedy edukacja jest częścią administracji publicznej, narzędzie Europejskiego Zarządzania Jakością dla sektora publicznego Powszechne Oszacowanie Struktury (CAF) może zostać użyte zgodnie z wymaganiami konwencji STCW jako punkt początkowy rozwoju modelu, który pozwoli na ocenę ilościową instytucji Morskiej Edukacji i Szkolenia (MET). Ocena rezultatów i procedur jest zwykle opisywana jakościowo jako ocena słowna, SA to części raportu lub są sumowane w raporty statystyczne. Rozmyta argumentacja zezwala na przekształcenie podejmowania decyzji jakościowych w ilościowe. Do tego celu sugerujemy modelowanie rozmyte, które daje ilościową ocenę efektywności edukacji. Ewaluatory słownej oceny mogą być lingwistycznymi zmiennymi wejściowymi dla rozmytego modelu decyzyjnego, opartymi na zaleceniach CAF i jakości instytucji szkoleniowych.

1. INTRODUCTION

Maritime transportation is the most important form of transport activity, since 90% of world trade takes place by sea. For efficient and safe transportation, the knowledge and skills of seafarers is vitally important. One must also note that maritime transport generally is international, performed by ships of various flags that are managed by companies from all around the world and operated by a multi ethnic crew. So the knowledge must be set internationally in uniform standards of competence and certification for seafarers, prescribing the minimum qualification of seafarers. In 1978, the International Maritime Organisation (IMO) (then known as the Inter-Governmental Maritime Consultative Organization - IMCO) adopted the STCW Convention (Standards of Training, Certification and Watchkeeping of Seafarers), which was the beginning of unifying standards. This was only the first initial step towards standardization, since in 1995 a revised STCW Convention was released which is still in use today.

The revised STCW code introduced the matter of quality standards in Maritime Education and Training with consequently the related quality control and quality assurance requirements. The revised STCW explicitly tackles the matter of quality standards in the chapters I/8 of the Annex, Part A and Part B, [11]. The relevant points from Section A I/8 "Quality standards" are: "*All training, assessment of competence, certification, endorsement and revalidation activities carried out by non-governmental agencies or entities under its authority are continuously monitored through a quality standards system to ensure achievement of defined objectives including those concerning the qualifications and experience of instructors and assessors, where governmental authorities perform such activities there shall be a quality standards system, an evaluation is periodically undertaken, by persons not involved in the activities concerned, information regarding the evaluation shall be communicated to the Secretary General of IMO.*" [11]

Any MET institution must be accredited by an authorized professional or governmental authority, either national or international, in order to ascertain that a continued high standard of quality is assured [23].

Here arises the question: which model is appropriate to determine the requirements have been satisfied? According to STCW convention [11] in Section B-I/8 "*Guidance regarding quality standards*" it is stated that "*Each Party should take account of existing national or international models*". [11]

These models should incorporate the following key elements:

- an expressed policy regarding quality and the means by which such policy is to be implemented;
- a quality system incorporating the organizational structure, responsibilities, procedures, processes and resources necessary for quality management;
- the operational techniques and activities to ensure quality control;
- systematic monitoring arrangements, including internal quality-assurance evaluations, to ensure that all defined objectives are being achieved; and
- arrangements for periodic external quality evaluations as described in the following paragraphs.

Due to the fact that any model has its deficiencies and advantages, the administration of each Party of STCW convention should decide which model is suitable for them. At the same time, in accordance with the principle of autonomy, each higher education institution has been able to choose a quality assurance system suitable for their institution (e.g. based on the ISO standards, EFQM, BSC, CAF or a self-developed QA system). [1]

The most important fact for quality is to not decrease the existing standards but try to keep them growing (see Fig. 1).

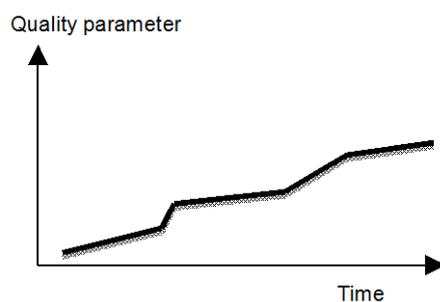


Fig. 1. Graphical representation of quality increase over time
Rys. 1. Graficzne przedstawienie wzrostu jakości w czasie

To achieve continuous growth it is necessary to measure the quality elements, detect deficiencies and take appropriate corrective measures. If those corrective measures are appropriate, the output should show better results. The simplified model is shown by diagram in Fig. 2.

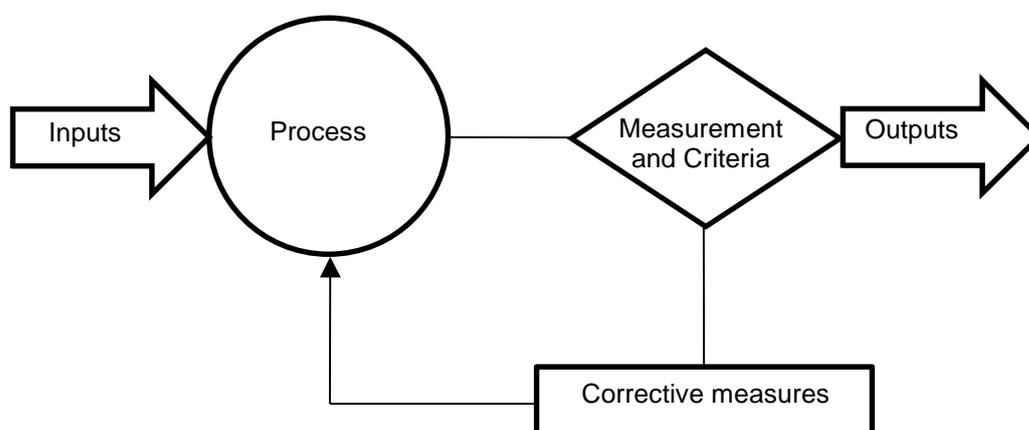


Fig. 2. Diagram of the evaluation and corrective procedure
Rys. 2. Diagram oceny i procedury naprawczej

At this point, it is necessary to pose the question: which are the elements in the process to assess and which criteria for assessment must be used? Practically every institution has its own system with its anomalies and particularities, so it is difficult to establish a method, which is suitable for all institutions.

2. STANDARDS FOR THE PUBLIC AND EDUCATIONAL INSTITUTIONS

One of the models, which is suitable for public institutions, including educational and training institutions, is the European Quality Management tool for the Public Sector - Common Assessment Framework (CAF). The CAF was primarily designed as a self-evaluation tool for public sector organisations at both local and national levels. The model is also intended to facilitate the introduction of more detailed evaluation criteria into the public sector evaluation process. Its content and structure follow the same logic as well-known Quality Awards models [14, 18]. The model involves five evaluation areas describing operations ('enablers'): leadership, strategy and planning, human resources management, partnerships and resources, and process and change management. Results are presented in the following evaluation areas: people results, customer and citizen-oriented results, society results

and key performance results. The model is also used to identify good practices within public administration in different countries. [5, 7]

The Common Assessment Framework (CAF) is a Total Quality Management (TQM) tool based on the Excellence Model of the European Foundation for Quality Management (EFQM) and the model of the German University of Administrative Sciences in Speyer [3]. The CAF is a model in which all the requirements to improve performance organizations across Europe in the public sector are structured in a simple manner through the use of quality management techniques.

The CAF has four main purposes [16, 18]:

- familiarise public administration with the principles of TQM and with the use and understanding of self-assessment, from the usual “Plan-Do” sequence of activities to a more effective “Plan-Do-Check-Act (PDCA)” cycle;
- facilitate the self-assessment of public institutions to obtain a diagnosis of the situations and actions needed for improvement;
- unify the various models used in quality management;
- facilitate benchmarking between public institutions.

2.1. Adaptation of CAF standard to Maritime Education Institutions

Since education is part of the public administration, the University is also a system made up of a series of elements: inputs, processes, resources, products and aims (see Fig. 3). The objectives of a University are: teaching, fulfilment of social needs, the promotion of international student mobility, research, postgraduate studies and services to the university community. In general, these objectives are common to university institutions from all the countries within the EU [13, 17].

Universities are often measured by some of these aspects, e.g. by questioning of students or by the introduction of generic quality ISO standards to the market segment, but an integrated evaluation model does not yet exist. Therefore, we propose a modified CAF which also includes requirements that are particular to this field.

The Maritime Education and Training Institutions, as part of a public university, could use the adapted CAF system as an assessment tool to verify the correct implementation of the previously mentioned STCW requirements.

3. DATA ANALYSIS AND DEFINITION OF THE FUZZY LOGIC MODEL

Evaluation of the study process and training is often verbal. Evaluators, based on their own assessment objectivity and CAF recommendations, extract from reports numerical coefficients and estimate a joint assessment. Fuzzy logic and linguistic variables could be good tools to define a proper evaluation model.

Many aspects of the process are evaluated verbally, so it seems useful replacement probability and statistical approach with fuzzy reasoning based on the credibility theory. Distribution functions could be also used to define the shapes of fuzzy membership functions. Evaluation scale used in the CAF panels and assessments obtained through the panel evaluations could be a good starting point to define input variables' membership functions, since values and positions of the linguistic variables terms could be defined on the base of this data analysis.

Since the proposed model is just the first step in the process of creating a model of evaluation, all input linguistic variables are defined with three terms (Low, Medium and High) that specify the degree of deployment and implementation of the approach and in doing so replace and simplify the scale that is used in the CAF manual.

Evaluation of the MET institution efficiency could be done by a multicriteria analysis (MA) approach; since some evaluations are not numerical it seems suitable to upgrade the analysis by fuzzy approach. Fuzzy multicriteria analysis (FMA) is based on the comparison of fuzzy numbers that is

generally very complex. Many authors have developed alternative methods of comparison that are simpler e.g. degree of optimality or integer programming approach, see [2, 21].

In this article we based the comparison of fuzzy numbers on a set of rules. In this way we rank the alternatives and define the values of the output variable.

Multicriteria decision making consists in ranking a set of alternatives A respect predefined criteria C , see [10, 12, 22, 23]. In this paper, evaluators are the decision makers (DM) that evaluated the MET institution on the base criteria set $C=\{C_1=\text{"Staff assessment"}, C_2=\text{"Student assessment"}, C_3=\text{"Ship-owner assessment-Customer assessment"}\}$ and selected-rank marks from the alternatives set $A=\{A_1=\text{"Negative evaluation-corrective measures required"}, A_2=\text{"Average evaluation-corrective measures optional"}, A_3=\text{"Positive evaluation-corrective measures not required"}\}$. In Fig. 3 is proposed the structure of the FMA model.

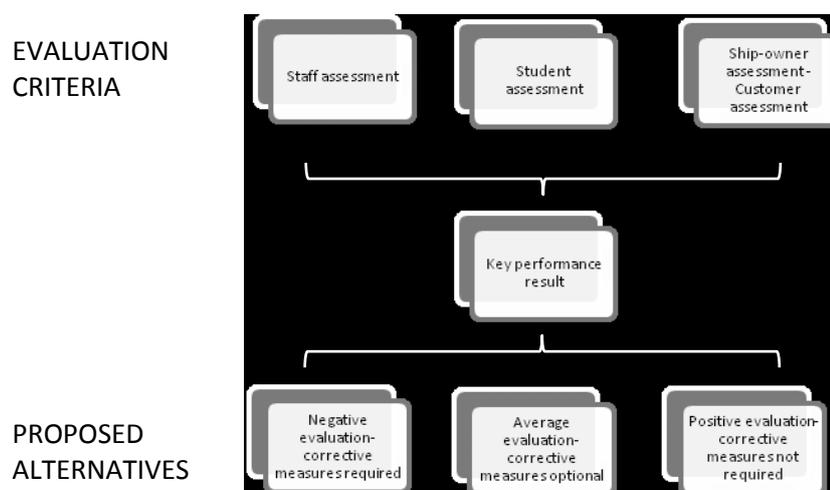


Fig. 3. Structure of the FMA model for MET institutions
Rys. 3. Struktura modelu FMA dla instytucji MET

Since the established model is only the first step, we decided to reduce the eight evaluation criteria of the CAF panel to three.

The evaluation process could become more objective and standard since the recommendations, requirements and the cumulative scoring system, based on "Plan-Do-Check-Act" (PDCA cycle), of the CAF manual are all included in the fuzzy rule blocks. The comparison of alternatives is structured on the base of Fig. 3 in three rule blocks, one for each criterion.

All assessment processes are performed, through the evaluation of the Plan, Do, Check and Act stages. Membership functions of all variables are linear. Membership function of a low term is S shaped, membership function of a medium term is triangular and membership function of the high term is Z shaped. The proper position of the linguistic term is determinate on the base of the statistical analysis of the previous assessment panels. Generally linear membership functions are adequate to define the first model. The study of the data obtained with panel evaluations could be used to define more appropriate membership functions.

Despite the input variables being defined in the same way respect the evaluation criteria (Staff assessment, Student assessment and Ship-owner assessment – Customer assessment) in each case they represent different aspects of the estimation process.

In the article was defined a rule block for each criteria. Rules have been formulated to rank the set of alternatives according to the CAF manual recommendations and priorities of the experts.

The Key performance linguistic result is computed from the Staff assessment, Student assessment and Ship-owner assessment – Customer assessment.

The output linguistic variables are also defined by three terms with linear membership functions. The crisp numerical values are computed by the Centre of Maximum (CoM) defuzzyfication method. CoM first determines the most typical value for each term and then computes the best compromise between the fuzzy logic inference results. The CoM method is used very often in fuzzy logic applications, since the obtained crisp result has all the properties of partial values, [8].

In the Key performance result rule block, the final crisp numerical assessment is computed by the Mean of Maximum (MoM) defuzzyfication method, which delivers the "most plausible result" and selects the typical value of the term that is most valid, [8].

Fuzzy production rules conditions consist of four preconditions linked together by AND operator. The fuzzy inference – aggregation in the IF-part of the rules is done by the minimum operator (MIN) as an extension of the classical intersection of sets to fuzzy intersection [25].

Results' aggregation is done by maximum operator (MAX) where only the dominant rules are evaluated.

The key performance evaluation is obtained by the decision maker (evaluator) through a ranking process of alternatives A_j respect criteria C_i . The degrees of the membership functions $\mu_{ij}(x)$, computed on input variable x , are the ranks computed on the base of the rules grouped in four rule blocks:

(1) *Staff assessment* [**C1**] The Staff assessment rule block is composed of rules that emphasize those criteria of the study process related to the staff: academic qualifications, professional experience, research activity, administration services, availability of information material, clear guidelines and advice. The most important aspects are planning and checking, see [19].

(2) *Student assessment* [**C2**] The Student assessment rule block is composed of rules that emphasize criteria of the study process that are important to students: library services, IT support, education material, adequate laboratories, courses structure, accessibility and execution (do phase). See [19].

(3) *Ship-owner assessment – Customer assessment* [**C3**] The Ship-owner rule block is composed of rules that emphasize aspects of the study process that are important to ship-owners: qualifications, specific skills and courses structure info. Important are execution (do phase) and verification (check phase). See [19].

(4) *Key performance result rule block* In this rule block the assessment of the key performance which is a compromise between the Staff assessment, Student assessment and Ship-owner assessment – Customer assessment is computed. In spite of the other decision blocks where some aspects have been deliberately highlighted in this case, the final evaluation is computed objectively, mid-terms are not favoured.

The fuzzy multicriteria approach could be summarized with the following steps:

- *Step 1:* Definition of a sample of MET institutions as a basis in the definition of the fuzzy evaluation model.
- *Step 2:* Statistical analysis of the data regarding previous panel evaluations of the MET institutions (mean values computation, standard deviation computation and confidence interval computation).
- *Step 3:* Definition of the input and output linguistic variables term position and definition of the linguistic variable membership functions. At the beginning the variables could all have linear membership functions, based on the idea of using the fuzzy prospective instead of the statistical point of view to make a correspondence between confidence intervals and triangular fuzzy numbers, since membership grades and confidence levels have the same properties, see [15, 20].
- *Step 4:* Development of a set of rules (Rule block) for criterion that allows creating a MET institution evaluation that rank the alternatives (terms of the output variable) according to the examined condition. In this case ranking means that for each term of the output variable is computed the membership grade as a term of comparison in the alternatives ranking procedure.
- *Step 5:* Group (rank) the obtained marks in a joint assessment.

4. EMPIRICAL DEFINITION OF RULES AND VARIABLES IN THE FUZZY MODEL

In this section the authors practically explain the steps that are part of the presented fuzzy model and compare the obtained results with those obtained by the classical panel evaluation model. We did not perform a total evaluation, but just a part of both methods was used, since currently, to our knowledge, such evaluation process are not yet in use in MET Institutions; therefore, total reports are not available.

Governance and control of higher education through national quality regimes vary, but quality assessments by external expert panels play a crucial role in most countries [1]. The expert's evaluation is based on their knowledge and experience.

Assessment through the CAF model is based on the use of predefined assessment panels showing achievements, conditions and associated estimates from 0 to 100. Estimation of the process is cumulative.

We used guidelines for scoring that are proposed in CAF 2006. In this manual two ways of scoring are presented: the classical CAF scoring, that is, the updated version of the CAF 2002 assessment panels and the fine-tuned CAF scoring, which allows for a more detailed analysis of sub-criteria. The PDCA-cycle is the fundament of both ways of scoring.

We decided to use the fine-tuned CAF scoring because it is a simultaneous way of scoring closer to reality since Maritime Education and Training Institutions could sometimes provide some activities (Do) without a complete plan (Plan).

The Enablers panel emphasises the PDCA cycle: progress is a spiral where in each turn of the circle, improvement may take place in the Plan, Do, Check and Act phases [4]. So the scoring process is used to indicate the areas where improvement is mostly needed and to indicate if the institution has to accelerate the trend or focus on the target achievements.

University of Ljubljana continuously monitors the quality of members and processes, but the CAF model for public sector is not used. We have used the Report on Quality Assurance for year 2012 that is published on the web site of the Faculty of Maritime Studies and Transport of the University of Ljubljana to create scoring with CAF 2006 model [9], in this first step we have examined only the Customer assessment part of the report.

In Table 1 the assessment panel which is defined on the basis of the tables given in the CAF 2006 manual is proposed. Evaluation of each step of the PDCA cycle must be entered into a general table by taking into account the specificity of the Customer assessment aspect, where the study process aspects are examined and assessed more rigorously.

In Table 2, it is explained how to set a trend from the computed score in a Public and MET Institution.

Is very difficult to obtain detailed data on the evaluation of public institutions, for this reason we decided to form a team of persons that are familiar with TQM and panel procedures of evaluation to compile the CAF evaluation panels in accordance with the evaluations of the Report on Quality Assurance for year 2012 for the Faculty of Maritime Studies and Transport of the University of Ljubljana. Statistical analysis of the data provides the foundation for Step 3 and the definition of the membership functions of the input and output variables. These evaluations could be also used to improve the system of rules (Customer assessment aspect) that expresses the opinion of the evaluators.

The Fuzzy model is designed by FuzzyTECH 6.00 Professional Edition and includes all the factors and evaluation methods that are part of the CAF manual. The fuzzy model simplifies the assessment method, because more on-going evaluation through the tables is not necessary since all the conditions and scales are already entered in the structure of the model. The fuzzy approach allows the direct use of verbal estimates as input linguistic variables in the model. Such an approach allows a uniform interpretation and more objective evaluation of the institution. Assessment of the fuzzy system is very flexible and permits one to provide an assessment on Maritime Education and Training Institutions even if sometimes activities are provided (Do) without complete planning (Plan).

Table 1

Assessment panel

PHASE	SCALE	0 – 10	11 – 30	31 – 50	51 – 70	71 – 90	91 -100
	EVIDENCE	No evidence or just some ideas	Some weak evidence, related to some areas	Some good evidence related to relevant areas	Strong evidence related to most areas	Very strong evidence related to all areas	Excellent evidence, compared with other organisations, related to all areas.
PLAN	Planning is based on stakeholders' needs and expectations. Planning is deployed throughout the relevant parts of the organisation on a regular basis.						
DO	Execution is managed through defined processes and responsibilities and diffused throughout the relevant parts of the organisation on a regular basis.						
CHECK	Defined processes are monitored with relevant indicators and reviewed throughout the relevant parts of the organisation on a regular basis.						
ACT	Correction and improvement actions are taken following the check results throughout the relevant parts of the organisation on a regular basis.						
						Total /400 SCORE /100	

Source: EIPA European Institute of Public Administration [6]

Table 2

Trends and Target Panel

SCALE	0 – 10	11 – 30	31 – 50	51 – 70	71 – 90	91 -100	
TRENDS	No measurement	Negative trend	Flat trend or modest progress	Sustained progress	Substantial progress	Positive comparison with relevant organisations for all results	
TARGETS	No or anecdotal information	Results do not meet targets	Few targets are met	Some relevant targets are met	Most of the relevant targets are met	All the targets are met	
						Total /200 SCORE /100	

Source: EIPA European Institute of Public Administration [6]

As expected, the result obtained is very close to the one obtained using the fine-tuned CAF 2006 scoring, but in this case it is not necessary to additionally highlight the Customer assessment aspect, because the rules of the Ship-owner - Customer assessment block have already done it. Therefore, the impact of evaluators to the final assessment is reduced.

5. CONCLUSIONS

Methods presented in this article are only the first step to the unification of assessments within MET institutions. Our purpose was to unify the evaluation methods that are used today in the public sphere (CAF 2006), specifically that of education and training in the maritime sector (STCW Convention). Joint evaluation of all these aspects provides a global assessment of future seafarers. In this article Fuzzy approach is proposed as alternative to classical panel (statistical) evaluation, the creation of a block of rules that define the final evaluation allows to minimize the subjectivity of assessment, or at least to make it common to all evaluators.

It is known that the comparison of scores obtained with CAF is of limited value if done between different institutions; the fuzzy approach reduces this risk because it minimizes the subjectivity that can result from inexpert evaluators.

This allows for the appropriate and prompt corrections that positively influence the educational and organizational processes of MET institutions, but also the relationship with the shipping industry, thus guaranteeing adequate skills and training of staff present in a crew.

This article has highlighted the key aspects related to the evaluation method CAF:

- Quality approaches,
- Guideline for improvement of activities, and
- Recognition of Good Practices.

Fuzzy logic could also be used to define an assessment tool that incorporates quality recommendations for public sector and particularity from the STCW conventions. Rules that are common for all evaluators that use the model reduces the human impact and produce evaluations that are comparable.

We hope that the proposals could become a useful tool for periodic and regular use (quality reviews and audits), which allows for the consolidation of the relationships between MET institutions and employers to ensure safety and quality shipping.

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