Automatized SWOT Analysis of the Quality Level in Higher Education Institutions

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Abstract

The process of evaluation and accreditation in higher education is time-consuming and experts in different professional fields are involved. The main objective of each accreditation procedure is to measure the quality level in the higher education institution and to end up with a set of recommendations about the most critical weaknesses. A big challenge during this evaluation is to determine the strengths and the weaknesses of higher education institutions (HEIs). This is part of the SWOT analysis, which gives information about the Strengths, Weaknesses, Opportunities and Threads of each institution. The SWOT analysis at the HEIs including the process of determining the weaknesses and the strengths of the institution can be maintained during the accreditation procedures and can be automatized. Different approaches for this automatization, based on a tree of indicators, grouped by the Standards and guidelines for quality assurance in the European Higher Education Area (ESG), are discussed in this paper. Automatized recommendation generation by using software tools is also coupled with the presented approaches.

Keywords

Quality Evaluation in Higher Education, Automatized SWOT Analysis, Automatized Recommendations Generation

1 Introduction

Evaluation and accreditation in higher education (HE) involves experts in different scientific areas (professional fields), administrative and management staff [1, 2, 3]. Accreditation procedures vary in type and duration. In order to achieve to measure the quality of HE, accreditation agencies in Europe use The Standards and guidelines for quality assurance in the European Higher Education Area (ESG) [4]. The ten standards in ESG give the framework to cover all the necessary circumstances, needed to provide an efficient educational process. Each of these standards has a given weight, used to determine its significance. The National Evaluation and Accreditation Agency in Bulgaria (NEAA) [5], applies the ESG too. Its staff created a detailed criteria system, based on the ESG, that includes a variety of different criteria. These criteria, grouped by the standard are equipped with the rules for the criteria implementation proves. The whole process of accreditation is based on the ESG and it aims to measure the level of its fulfillment.

Each accreditation procedure includes several phases and commonly takes a lot of time [6, 7]. It starts with the creation of the self-evaluation report by the staff of the higher education institution (HEI). The report is created by proving the fulfillment of the criteria, based on ESG. After this report is completed, a site visit of a team of external reviewers is organized at the HEI. The experts in this team have to create an evaluation report, based on the self-evaluation report and their impressions during the site visit. They have to determine the level of fulfillment of the criteria, based on ESG. A significant

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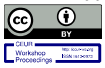

part of the evaluation report is its conclusion. The experts have to give their grades and make recommendations to the HEI. The recommendations are one of the key points in the report. They are used to focus on the most significant weaknesses of the HEI, according to the accreditation procedure type. These recommendations have to be taken into account by the HEI and their fulfillment is checked by the following next accreditation control. The accreditation grade of the HEI is influenced by the level of fulfillment of these recommendations. The external reviewers have to give the most appropriate recommendations in order to increase the quality of education in the HEI. The basic difficulties that the experts in the reviewers' team face are related to the fact that there is no public, structured information about the situation in the HEIs, that can be used for analysis and comparative decision-taking. The lack of this data leads to subjective grades and inaccurate recommendations, that do not reflect the real situation in the explored professional field. In fact, the members of the reviewers' team have to make part of the so-called SWOT analysis of the HEI, focusing on the accredited professional field. SWOT (Strengths, Weaknesses, Opportunities, and Threads) analysis [8, 9] will show the summarized information about the situation at the HEI, applicable to the quality assurance process.

This work focuses on the first part of the SWOT analysis and an automatized determination and the strengths and weaknesses of the HEIS is described in it. The other important point in the process of quality evaluation is the generation of a list of recommendations for the HEI, according to the "weakest" standards/criteria, that are determined. The criteria framework is based on a set of indicators grouped by the standards in the ESG.

2 Automatized SWOT Analysis of the HEIs

The main objective of this research is to automatize the process of the first two parts of the SWOT analysis for HEIs and create meaningful recommendations for each HEI in a given professional field These will help the HEI to take appropriate actions to overcome the reasons that lead to a decreased quality of education. The SWOT analysis will be implemented during the process of accreditation of the HEIs and will serve to improve the quality of education provided to them. There are two main steps in succeeding do this:

1. Automatized SWOT analysis: determining the weaknesses and the strengths of the HEIs in different professional fields;
2. Generating meaningful recommendations according to the determined weaknesses. If the goal is accomplished it can lead to an objective evaluation of the situation in the field and the team of external reviewers can give a set of recommendations for each HEI, according to the detailed and summarized analysis of the collected data from the HEIs.

2.1 SWOT Analysis (Strengths and Weaknesses)

The whole process of accreditation has to be provided simultaneously (at one and the same time) for all of the HEIs. This circumstance will give the opportunity to make comparisons, based on different criteria, without any differences in the current observed results. The weaknesses and the strengths of the HEIs can be determined by using a method that includes several different phases:

Phase 1. Collecting primary quantitative data about the situation in the concrete professional field in each HEI.

Phase 2. Transforming the collected information, in order to make it appropriate for comparison, according to the accreditation periods and the size of the HEI.

Phase 3. Choose and apply an approach to determine the weaknesses and strengths of the HEIs.

During the first phase, a set of primary quantitative data has to be collected by the HEIs. The set consists of specific information about the situation in each HEI. Some exemplary information is: "Number of students", "Number of habilitated lectures" etc. The collected data is transformed to become appropriate to be used to compare the achievements of each HEI, according to a set of different criteria, called indicators. The process of calculation and transformations by applying different techniques and the results of several experiments with this data are presented in [10] The so-called z-transformation is the method that is used to calibrate the data to make it suitable for HEIs comparison. z-transformation is based on the application of several statistical operations:

1. Find the average value (Avg) of the values for each indicator.
2. Calculate the standard deviation (StDev), processing the same set of data.
3. Z-scores are finally calculated by the formula:

$$Z_i = \frac{Ind_i - Avg}{StDev},$$

where Ind_i is the value of each HEI for the each indicator

One important point here is to remove the data with a standard deviation higher than a concrete value (for example 2.5), in order to preserve the results from deformations. The final calculation includes a weighted total of the received in the previous step results. This will take into consideration the indicators that are more significant than others.

When the z-score is received it is used to make a comparison between data of different types (numbers, percentages, etc.). It also gives means to make a parallel between the HEIs' achievements, removing the impact of the differences in the periods of the accreditation procedures and the size of the HEI.

The above-described SWOT analysis is demonstrated by an example with 5 HEIs. A quantitative, transformed, and calibrated sample data is presented in **Figure 1**. The data shows the calibrated weighted values for 5 exemplary HEIs. This part of the table includes the first eight indicators in standard 4. In order to highlight the weakness of the HEIs, we are interested in the negative values, for example, those that are less than -1.5 (highlighted in the table's cells). In the example shown in Figure 1, the data is sorted by the indicators numbers.

Standard	Ind.	HEI 1	HEI 2	HEI 3	HEI 4	HEI 5
4	4.1	5,58	-3,14	-0,96	-1,73	0,25
4	4.2	-0,50	-0,50	-0,50	-0,50	2,00
4	4.3	-3,32	-1,64	-2,27	3,60	3,63
4	4.4	-1,50	-1,50	-1,50	-1,50	6,00
4	4.5	0,00	0,00	0,00	0,00	0,00
4	4.6	-0,95	-0,97	-1,06	-1,01	4,00
4	4.7	1,79	-2,41	-0,08	-1,96	2,66
4	4.8	-0,32	-0,92	1,94	-0,50	-0,20

Figure 1. HEIs' Weighted Values of the Quantitative Indicators after *Z-transformation*

After the z-transformation is complete, the results that are received can be analyzed. Two separate approaches for this analysis are used for the weaknesses and strengths determination: **Approach 1. Weaknesses by Standard**, and **Approach 2. Weaknesses by Indicator**. Both of them are described below.

2.1.1 Approach 1. HEI Weaknesses by Standard

The first approach **HEI Weaknesses by Standard** is based on the following principle: calculating the sum of all the negative values grouped by standard and selecting the highest absolute value of the negative sums. The standard with this highest absolute value is the potential standard with the worst achievements, compared with other HEIs. This "worst" standard is a candidate to be used for recommendation generation. Sorting the negative values in this "worst" standard will give detailed information about the most significant indicators that have an impact on the negative values. Choosing the top number of them (for example 3) will lead to detailed information about the weaknesses of the HEI in this professional field. An exemplary summarized and analyzed data is presented in Figure 2.

It is easy to find out that the recommendations have to concern the "worst" standard and its "worst" indicators. In this example, the focus is on HEI 5. The data shown in the table is summarized according to the negative values of the indicators for HEI 5. It is obvious that the "worst" standard for HEI 5 is standard 5 because its absolute value of the negative ones is 10.79, greater than 4.66 and 5.89. Looking

at the "worst" indicators in standard 5, 5.15, 5.6, and 5.17 are the indicators with the greatest absolute value. These three indicators are:

5.15 Average faculty citation index.

5.6 Annual average relative share (in percentages) of lecture hours (compared to their total number in the forms of education for the period) delivered by habilitated lecturers.

5.17 Number of start-ups with a subject of activity in areas of the professional field, and with a minimum of two years of activity in the period.

Indicator 5.15 shows the lack of citations and the fact that the faculty staff has to work harder to publish more works in referenced editions. So the first recommendation may be: "The HEI must increase the publication activities". Indicator 5.6 shows that there are not enough habilitated lecturers employed at this HEI. The recommendation has to concern the process of hiring habilitated lecturers and increase the support of the academic growth of the not habilitated faculty staff. In the same sense, the other negative values can be used to formulate the recommendations. An important point here is what is the limit of the explored negative values and whether are there relationships between the indicators, that are with the least values.

Standard	Ind.	HEI 1	HEI 2	HEI 3	HEI 4	HEI 5
4	4.15	1,51	-2,25	0,82	2,41	-2,49
4	4.11	-1,53	0,97	3,50	-1,25	-1,69
4	4.10	0,71	0,71	0,71	-1,85	-0,28
4	4.8	-0,32	-0,92	1,94	-0,50	-0,20
4 Total		**0,36**	**-1,49**	**6,98**	**-1,19**	**-4,66**
5	5.15	4,08	2,11	0,58	-3,93	-2,84
5	5.6	2,48	-4,50	3,35	1,14	-2,46
5	5.17	-1,50	-1,50	6,00	-1,50	-1,50
5	5.5	0,96	-2,07	5,41	-2,95	-1,36
5	5.4	3,98	-0,88	-0,96	-1,37	-0,77
5	5.14	3,95	0,21	1,67	-5,11	-0,72
5	5.12	1,64	-0,90	0,68	-0,79	-0,64
5	5.13	-1,46	2,90	-2,56	1,63	-0,50
5 Total		**14,12**	**-4,63**	**14,17**	**-12,88**	**-10,79**
6	6.1	1,55	1,80	1,54	-2,25	-2,64
6	6.4	0,50	0,50	0,50	0,50	-2,00
6	6.9	-3,69	5,40	-0,79	0,33	-1,25
6 Total		**-1,64**	**7,69**	**1,25**	**-1,42**	**-5,89**
Grand Total		**12,84**	**1,58**	**22,40**	**-15,49**	**-21,33**

Figure 2. Weaknesses of HEI by Standard

Several important concerns about the Weaknesses by Standard approach, that is presented in this section of the paper, have to be placed here:

1. Several standards with similar total absolute values. Determining only one standard considered "worst" will lead to missing some important recommendations. In order to overcome this situation, additional analysis of the data have to be done. Comparing the absolute values of the negative total sum of the different standards. A value for differentiation has to be chosen;
2. Cumulative recommendations can be generated. Some of the indicators are related to others. This means that one recommendation can be formed to overcome more than one "negative" indicator. These connected indicators have to be identified. If some of them are negative values, the cumulative recommendation has to be generated.

2.1.2 Approach 2. HEI Weaknesses by Indicators

The second approach **HEI Weaknesses by Indicators** that can be used to determine the HEI's weaknesses is not to look for the "worst" standard, but to try to find the "worst" indicators. This method

uses a simple sorting of the quantitative values of all the indicators in descending order. The top values (for example 3) can be chosen as the potential recommendation generation. In this case, the top values can be indicators of different standards. This information shows that the HEI has problems with quality assurance relative to separate areas in higher education. Exemplary data, sorted without grouping by standards is shown in Figure 3.

Ind.	HEI 1	HEI 2	HEI 3	HEI 4	HEI 5
5.15	4,08	2,11	0,58	-3,93	-2,84
6.1	1,55	1,80	1,54	-2,25	-2,64
4.15	1,51	-2,25	0,82	2,41	-2,49
5.6	2,48	-4,50	3,35	1,14	-2,46
6.4	0,50	0,50	0,50	0,50	-2,00
4.11	-1,53	0,97	3,50	-1,25	-1,69
5.17	-1,50	-1,50	6,00	-1,50	-1,50
5.5	0,96	-2,07	5,41	-2,95	-1,36

Figure 3. Weaknesses of HEI by Indicators

The exemplary data shows that the "worst" indicators for HEI 5 are 5.15 (the same as using Approach 1), 6.1, and 4.15. There are indicators from three different standards 4, 5, and 6 which show that HEI 5 has weaknesses in all three. Some exemplary recommendation about indicator 6.1 may be: "The HEI has to include the accredited program more practical courses with the usage of specific equipment." As it was discussed in the previous sub-section some of the recommendations can combine two or more indicators. Such a situation can be observed here because the low value of indicator 4.15 shows that the number of students, who participate in practical education is not enough. This is related to the 6.1 indicator and the recommendation for 6.1 can be used for 4.15 too.

Analogously to the described above approaches that determine the weaknesses of the HEIs, the strengths can be identified too. The "best" standard and/or indicator for each HEI can be easily found if the total sum of the positive values grouped by the standard or indicator is calculated. This is important information about the highest achievements of the HEIs, according to different standards.

2.2 Recommendations Generation Strategies

After the weaknesses of the HEI are determined, the next step is to generate appropriate recommendations, according to the "worst" indicators. Two different strategies can be applied in order to do this.

Strategy 1. **Accumulating recommendations**: while providing the process of accreditation and constructing the evaluation report, each expert team of reviewers has to write recommendations for a concrete HEI, depending on the accreditation procedure type and the professional field. These recommendations can be stored and can be used for future procedures if they are connected to one or more indicators. The software system that provides means to conduct the accreditation process, is based on a predefined set of indicators. The next step is to choose from the list of collected recommendations for this concrete indicator to a group of indicators and select the most appropriate. This will help the team of reviewers to reuse previously formulated recommendations. Additional information about the usage of each recommendation can be displayed in order to make the selection easier. The key point here is to use the indicators and the collected recommendations for future procedures.

Strategy 2. **Recommendations generation can be based on the relationship between the indicators** and the primarily collected data from the HEIs. If the indicator measures the relative share of the lectures and it is found that this indicator is one of the "worst" the recommendation has to be focused on increasing the number of lecturers. The number of lecturers is one of the collected primary data. Templates for the most commonly used recommendations can be created by using each of the quantitative primary data, collected by the HEI [11]. The templates have to be created by experts. The experts have to take into account the primary data details. After the template recommendations are

created, the software system will automatically connect the "worst" indicators with one or more slots of the collected primary data. This relationship is based on the resource data used in the formula that calculates the value of the indicator.

3 Software System for Accreditation and Automatized SWOT Analysis

A software solution for automatizing SWOT analysis and recommendation generation can be used to help the team of external reviewers to increase objectivity and reduce manual efforts during the creation of the evaluation report. This solution is based on the presented above approaches and is part of a whole software system for the processes of evaluation and accreditation. This is a system for modeling processes for data accumulation and synthesis in higher education. Its architecture is explained in detail in [12. 13] The focus of the current research is on the way how the process of recommendation generation can be included in this system and which are the most important features that have to be created to assure effective usage of the software. Recommendations generation has to be added as a separate module, but this module will consume some of the resources provided by the whole system. The software modules that are related to the business logic of the recommendations generation are described in this section of the paper.

Module 1. Primary Quantitative Data Processing. The first important module that serves the accreditation procedure is to process the collection of the set of primary quantitative data. The staff, responsible for the accreditation procedure of each HEI will be able to enter this needed data, by using the means of the system. According to the criteria system, based on the ESG, a set of needed quantitative data has to be provided by the HEI. The sample form, used to enter the primary data is shown in Figure 4.

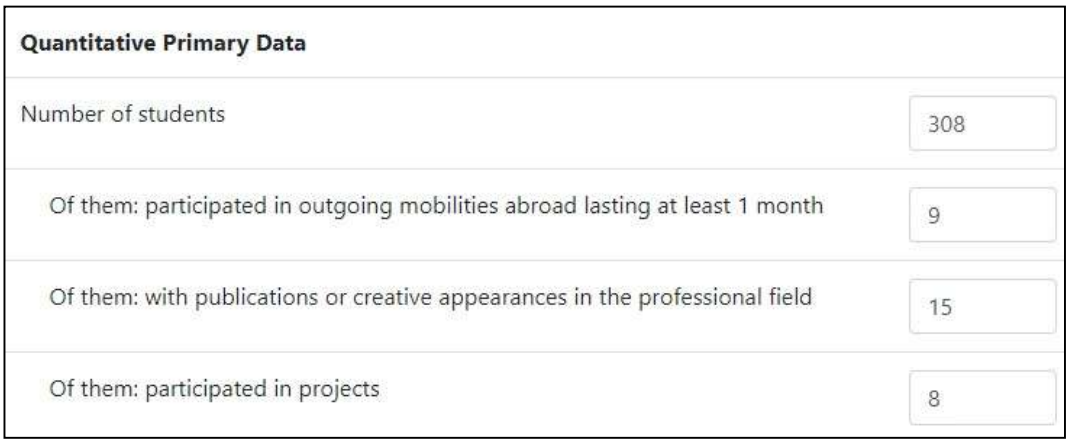

Figure 4. Primary Data Form (Sample)

Module 2. Indicators Tree Processing. The second significant module of the system is the one that is used to create the set of qualitative and quantitative indicators. Indicators are grouped by a standard and are placed in a tree data structure because the hierarchy of the standards and indicators has to be kept. Each indicator has a weight that is used for the final calculation when receiving the grades by indicators and the total grade at the end of the procedure.

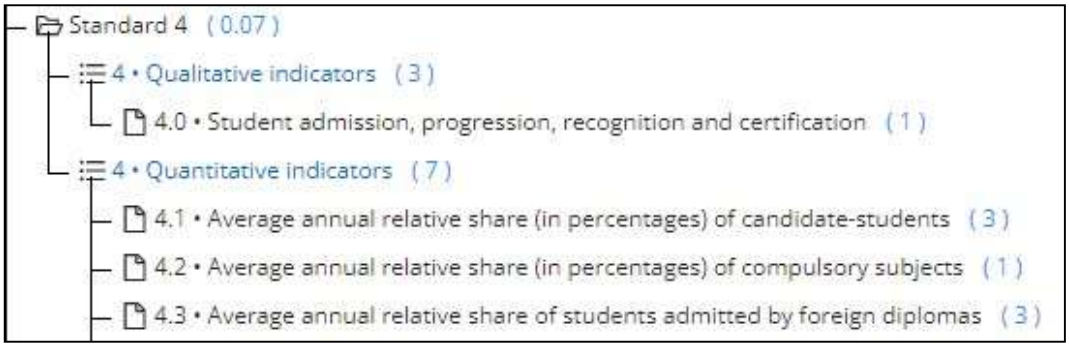

Figure 5. Indicators Tree

Information about standard 4 and one of its indicators is shown in Figure 6. The detailed information of this indicator is displayed and this indicator is used to measure if the candidate-students wish to study in the accredited major. The primary data related to this indicator consists of two values: number of the candidate-students whose first wish is to study in this program and the planned admission for the respective year. These two primary data will be used to make the necessary calculations. One exemplary indicators tree is presented in Figure 5. This part of the tree shows standard 4 with a weight of 0.07, relative to the other standards. Standard 4 has one quality indicator and three quantitative indicators, all of them entered with the help of the form shown in Figure 6.

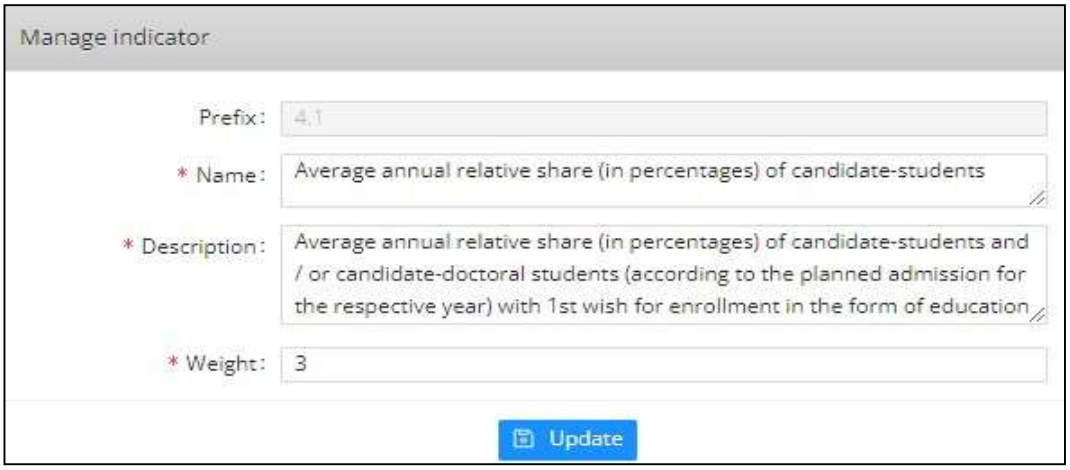

Figure 6. Manage Indicators Form

Module 3. Calibrating Quantitative Data. This module is doing the calculations and the transformation of the collected data, that will be used by the other modules of the system. It includes the relationships between the primary data entered by the HEIs and the indicators in the tree. Depending on the settings of each accreditation procedure it will provide the necessary calculations to make the data for one HEI appropriate to be compared with the data of other HEIs. The described above approach of the z-transformation of the data is also made by this module. This module will take resources from "**Primary Quantitative Data Processing**" and "**Indicators Tree Processing**". It will process resources to the "**Recommendation Generation**" module.

Module 4. Recommendation Generation. This module is responsible for the recommendation generation in the software system. It will communicate with the other modules and will proceed to manage the data collected from them. Its first part consists of the implementation of the business logic that determines the weaknesses of the HEI, which is implemented by the "**Calibrating Quantitative Data"** module. The next part of this module is the implementation of the two strategies for collecting a set of recommendations and using them in combination in order to achieve the best results. As a result of applying the two strategies a set of recommendations, that are related to one or more indicators will

be saved in the database. They will be reused in different accreditation procedures and their variety can be enlarged by giving the opportunity to add more of them.

4 Conclusion and Future Work

Different approaches for the automatized SWOT analysis to determine the strengths and the weaknesses of the HEIs are presented in this work. The process is maintained during the accreditation procedures of different types. At the end of the process, an automatized recommendations generation for HEIs takes place in this research. All the separate steps that have to be followed while achieving the automatized generation are explored in detail. An important part of the method used to solve the task is how to determine the weaknesses of each HEI (part of the SWOT analysis), based on the predefined tree of indicators which is created according to a given type of accreditation procedure. The Software implementation that serves the whole process is explained. Its different modules and the communication between them is part of the solution of the most important task that has to be solved: to achieve increased quality in education by applying the described above approaches and implementations and the reduction of the efforts done by the members of the external reviewers' team. The experts in this team are able to make the final grades and the recommendations in the evaluation report more objectively and will have fewer difficulties. If they use the presented software tools they will make a solid, well-founded decision based on the summarized situation in the whole professional field.

The following improvements will optimize the proposed approaches:

- Implementing techniques for measuring the "rating" of each recommendation. Storing information about its usage of it and applying means for analyzing the results;
- Making experiments and improving the software implementation.
- Assuring the relationship with the post-accreditation control processing.

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6 References

[1] M. Docheva, S. Gaftandzhieva, R. Doneva, G. Totkov, Model for quality evaluation in secondary education Edulearn20 Proceedings 3745-3755, 2020.

[2] A. Horvat, B. Radovanov, O. Sedlak, Z. Ciric, R. KorhecHigher, Analysis and Comparison of the Efficiency of the Education System of European Countries Using Data Envelopment Analysis, in: Proceedings of the – 14th International Conference on Education and New Learning Technologies, Palma, Spain. 4-6 July, 2022, doi: 10.21125/edulearn.2022.

[3] L. Popescu, Improving the Quality Management System in a University Cultural Center in Romania, in: Proceedings of the – 14th International Conference on Education and New Learning Technologies, Palma, Spain. 4-6 July, 2022, doi: 10.21125/edulearn.2022.

[4] "European Standards and Guidelines", ENQA, 2015, URL: https://www.enqa.eu/esg-standards-and-guidelines-for-quality-assurance-in-the-european-higher-education-area/.

[5] Bulgarian National Evaluation and Accreditation Agency, URL: https://www.neaa.government.bg/en.

[6] S. Gaftandzhieva, R. Doneva, G. Totkov, Dynamic Quality Evaluation in Higher Education, TEM Journal 7 3, 2018.

[7] M. Docheva, G. Totkov, S. Gaftandzhieva, R. Doneva, Hybrid model for quality evaluation in secondary education, IOP Conf. Ser.: Mater. Sci. Eng. 1031 012068, 2021.

[8] A. Sarsby, SWOT Analysis, 2016, ISBN 978-0-9932504-2-2.

[9] SWOT Analysis: A Theoretical Review, The Journal of International Social Research, Volume: 10 Issue: 51, August 2017, Doi: http://dx.doi.org/10.17719/jisr.2017.1832

[10] H. Kostadinova, G. Totkov Complex Assessment of Similar Objects in the European Higher Education Area, in: Proceedings of the – 14th International Conference on Education and New Learning Technologies, Palma, Spain. 4-6 July, 2022, doi: 10.21125/edulearn.2022.

[11] Y.E.I. Mansour, M. Ezzat, S. KhahroGeneric, Assessment Tool for Academic Program Accreditation, in: Proceedings of the – 14th International Conference on Education and New Learning Technologies, Palma, Spain. 4-6 July, 2022, doi: 10.21125/edulearn.2022.

[12] S. Gluhov, S. Atanasoff, E. Alendarova, G. Totkov, Monitoring System for Corporative Computer and Communication ICT Infrastructures, Scientific Works of the Union of Scientists in Bulgaria – Plovdiv. Series C. Technics and Technologies. Vol. XVII., ISSN 1311 -9419 (Print); ISSN 2534-9384 (Online), 2019.

[13] G. Totkov, S. Gaftandzhieva, G. Pashev, S. Atanasov, A System for Modelling of Processes for Data Accumulation and Synthesis in Higher Education, TEM Journal. Volume 9, Issue 4, Pages 1619-1624, ISSN 2217-8309, DOI: 10.18421/TEM94-38, November 2020.