Models for quality assurance in higher education area

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Abstract: *This paper examines some problems in quality assurance in higher education. The need to use specialized software systems to fully automate procedures and business processes for conducting assessment and accreditation procedures is motivated. Two quality assurance models are proposed, based on the idea of an automated transfer of information between higher schools and accrediting bodies - with stronger and weaker integration. The loosely centralized model provides greater opportunity for integration of the university's QA system with other internal systems of the institution and own control over business data. The highly centralized model minimizes the need for administrative support on the part of the higher school, but the possibilities for integration with available university systems are limited. A generalized net model of data processing for self-assessment procedures in higher education institution is also proposed in the paper.*

Keywords: Accreditation, Higher Education, QualityAassessment, Generalized Net Model.

1. Introduction

Quality assurance in higher education (HE) is an ongoing process that requires a lot of effort on the part of educational institutions and accreditation organizations. There are two main forms – ***internal and external quality assurance***. Higher education institutions (HEIs) build ***internal quality assurance systems*** and are free to establish their own rules and criteria for assessing various objects and subjects of the educational process. They are also subject to ***external assessment – accreditation performed by licensed national and international agencies***. They assess them on the basis of established and standardized criteria systems for quality assessment. In the general case, in external assessment the accrediting institutions require self-assessment reports from the HEIs, proving the implementation of the approved criteria system, and accompanied by a lot of evidence and documents. To receive higher assessment grades, ***HEIs build their internal quality systems in accordance with the criteria systems of the accrediting institution***. This undoubtedly motivates the main university units to meet the set criteria but also reveals ***prospects for formalization and centralization of the***

accreditation procedures. The possibility to create a centralized repository and a system for management and monitoring of accreditation procedures leads to greater transparency, objectivity and saves time, human and material resources.

Two models for quality assurance are proposed in this paper – one with stronger and another with weaker centralization, based on the idea of automated information exchange between higher education institutions and accreditation bodies. The presented models are based on the experience of the authors in building an automated system for quality assurance and accreditation COMPASS (Hadzhikoleva et al., 2016a), used in the University of Plovdiv "Paisii Hilendarski". They extend the strictly institutional constraints of COMPASS by providing a framework for building a national automated system for quality evaluation and accreditation.

2. Accreditation of higher education in Bulgaria

The need for commensurability of the quality of higher education in the European Union motivates the definition of uniform quality standards. European Higher Education Area (EHEA) is characterized by a wide variety of higher education systems, educational institutions, bodies for external evaluation and accreditation, socio-cultural differences and educational traditions. This makes it impossible to establish a uniform quality assurance system. It was therefore necessary to develop standards that are so general that they can be adapted to the specificities of education at a national level, while at the same time be so specific as to give a common concept and vision of quality of higher education in the European Union. In 2005, a significant step was taken in this direction. European Standards and Guidelines for Quality Assurance (ESG) in the EHEA were developed. They were accepted by the ministers responsible for higher education in the countries of the European Union. The document was last updated in 2015 (Standards and guidelines, 2015). It contains many standards and guidelines for their implementation and is used by many quality agencies in the EU. ESG does not define specific methodologies and procedures for quality assurance. Educational and accreditation institutions develop their own methodologies and criteria systems for assessment, in accordance with ESG standards.

Bulgaria is one of the countries that apply the ESG standard. Ensuring the quality of higher education in Bulgaria is carried out by the National Evaluation and Accreditation Agency (NEAA). It is the only specialized state body for assessment, accreditation and quality control of higher education in Bulgaria. It is authorized through the Higher Education Act (Higher Education Act, 1995) to approve criteria and procedures for assessment and accreditation and related documentation.

By 2023, 8 types of accreditation procedures have been approved, incl. institutional accreditation; program accreditation of professional field, specialty and doctoral program; assessment of distance learning; assessment of projects for opening and transformation of units, professional fields, etc.

The quality assurance procedures follow a general scheme and include several main activities – self-assessment, visit of an expert group, evaluation and post-accreditation control. If we ignore the specific administrative activities carried out in HEIs and NEAA, related to discussion, voting and preparation of administrative reports and decisions, the stages of an assessment procedure can be defined as follows:

• *Self-assessment*. The assessed institution provides a basis for conducting external quality evaluation by conducting a preliminary self-assessment and preparing a self-assessment report. It should be developed in accordance with the requirements of the criteria system of the NEAA for the relevant procedure and contain a self-assessment and analysis of the achieved according to the basic standards, which are the subject of the verification and assessment.

• *Visit of an expert group (EG) to the assessed institution*. The EG makes an on-site visit to the institution being evaluated, checks the information provided and if necessary, requests additional information. The EG prepares a report on the performed inspection, containing an assessment and specific guidelines for future actions aimed at improving the quality of education.

• *Evaluation*. After discussions and votes, the NEAA makes a final decision on the evaluation and is motivated by relevant opinions and reports.

• *Post-accreditation control*. It includes procedures for follow-up control in the educational institution, aimed at monitoring the implementation of the instructions given.

Accreditation procedures are conducted in a similar way in many European countries. They require a lot of time, material and human resources, for many reasons:

• *Universities collect, analyze and process a large volume of various types of data, incl. unstructured or semi-structured*. The information is collected by various administrative and educational units. In some cases, there are no established standards and often the same type of information is structured differently by the different units. Some of the information is processed manually, whereby updating already processed information requires re-processing and summarizing. If the educational institution does not have a unified repository of administrative and educational documents, there is the risk of providing duplicate information, using outdated data and documents, etc.

• *Members of the administrative and academic staff with different competencies* participate in the evaluation procedures. They are from different units, have different rights and responsibilities, different access to information, different opinions and vision of the quality of education, teamwork skills, etc.

Accreditation procedures are conducted periodically, the periods ranging from 3 to 6 years depending on the type of accreditation procedure and/or the

previous assessment. This is related to ***a few months' redirection of the efforts of a large part of the academic staff from the educational process to the accreditation procedure***. The university staff interrupt their main activities and make extraordinary efforts to prove compliance with the accreditation criteria and receive a high grade. Procedures for evaluation and accreditation in higher education must be a natural and integral part of the educational process. They should be held without much effort, unnoticed by students and academic staff. For this purpose, however, educational institutions must maintain repositories with up-to-date information about their activities, and accreditors must provide software tools for automated quality assessment. This is the only way to ensure an objective and indifferent assessment which would allow each higher education institution to identify its strengths and make an effort to improve its weaknesses.

## 3. Accreditation process by the university

Faculty and university quality commissions function to conduct the accreditation procedures at the higher education institutions. The staff of the faculty quality commissions (FQC) usually involves representatives of all primary units in a given faculty, including a representative of the student community. The FQC is responsible for conducting procedures for accreditation of professional fields and specialties of the regulated professions and doctoral programs. University quality commissions (UQC) are responsible for conducting institutional accreditation, project assessment and distance learning. It involves representatives of all faculties and branches, the student community, certified quality experts, etc. The FQC and the UQC have the responsibility to request, collect and process information related to the accreditation procedures and prepare the necessary reports and references. This is extremely complex in institutional accreditation because the main tasks are distributed within the UQC, assigned to the FQC, after which the information is collected by the academic staff, summarized at faculty first and then at university level. The careful enforcement of standards defining the way in which the main and primary units collect well-structured information from the academic staff is of great importance.

Many higher education institutions have built and maintain software systems for the publishing and research activities of the academic staff, but it is not always possible to extract all the information necessary for accreditation automatically. The important factor for this is the way this information is structures in the university system, and whether it complies with the requirements of the NEAA. In case the university does not have its own centralized software system, this information is collected by the academic staff by departments, summarized at the faculty level, and then at a university level. This creates the risk of making mistakes – e.g. re-reporting the same publications, especially if they are co-authored with lecturers from the same faculty. Various applications are usually used in practice which partially automate different quality assurance activities. Some types of them are presented in Figure 1.a. and Figure 1.b.

Many higher education institutions lack a system supporting the creation of a self-assessment report. In this case, the distribution of tasks for its preparation becomes hierarchical: the NEAA opens an accreditation procedure and notifies the university; the university accreditation commission allocates tasks for preparation of reports and preparation of texts for the individual standards to the corresponding units; the units collect information from various registers, university software systems with structured or non-structured data, as well as non-digitized information (Figure 1.a). Despite the data collected by individual employees, the creation of the final version of the self-assessment report is no less difficult due to the need to summarize the data that is provided in different formats and bring the texts into a document with a common literary style.
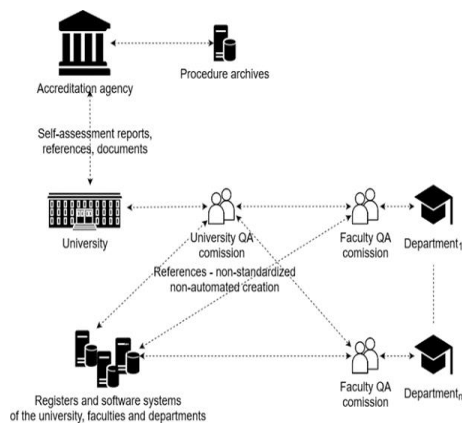
Figure 1.a. Model for preparing a self-assessment report without QA system
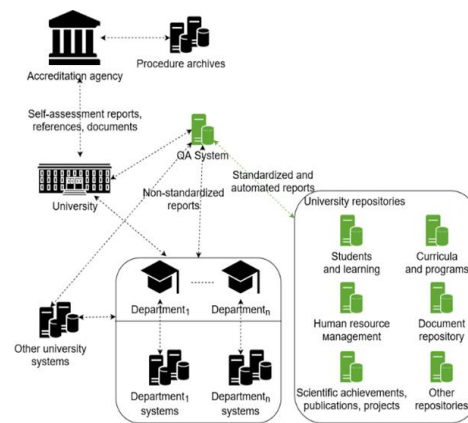
Figure 1.b. Model for preparing a self-assessment report with QA system

The availability of software tools supporting the creation of a self-assessment report provides opportunities for: ongoing control and monitoring of the activities for compiling a self-assessment report; automation of the access to standardized reports from internal and external registers; facilitated cooperation between the participants in the assessment procedures, etc. (fig. 1.b) (Hadzhikolev et al., 2016). There are no software solutions that fully automate the process of quality assessment or accreditation in higher education.

4. Weakly centralized model for accreditation

One possible approach for automation of the accreditation procedures is by building a centralized system of the accreditation agency and independent university systems for quality assurance (Figure. 2a). Each university QA system automatically retrieves the necessary accreditation data from the university repositories (students and learning, curricula and programs, human resource

management, document repository, scientific achievements, publications, projects, etc.). Another part of the information concerning justifications, explanations and conclusions is entered by university persons in charge and quality experts. At a certain point in time, the information from the university QA system is exported to the QA system of the accrediting institution.
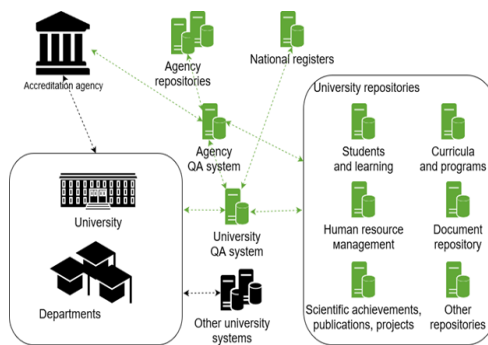
Figure 2.a. Process of accreditation of a HEI
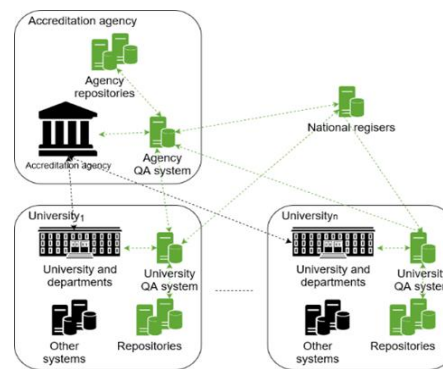
**Figure 2.b.** Process of accreditation in the system of HE

The advantages of this approach are the opportunity for each higher education institution to build its own QA system in accordance with its needs and its own information ecosystem, in accordance with the standards and protocols set by the accreditation agency. The provision of standardized QA systems receiving automated updates, easy to independently install, configure and use, would be a significant facilitation. Also, the existence of a centralized system of the agency means that universities would not create their own solutions but would only use the opportunities provided by the agency.

The advantages of this approach also determine its disadvantages. The creation of their own solution or the maintenance of a standardized application by the universities requires the presence of specialized IT specialists in each higher education institution. Creating a standardized University QA system is a laborious task that must take into account the availability of many different university repositories and other software systems. Of course, the universality of such a system is desirable but not mandatory.

5. Highly centralized model for accreditation

The creation of a national centralized software system for quality assurance would allow more effective software support, provide transparency and monitoring of the quality of education. The highly centralized model proposes the use of a centralized cloud-based accreditation system. The system supports a module for the

QA agency as well as configurable modules serving the accreditation processes for the individual higher education institutions (fig.3). The use of a unified system enables the establishment of conveniences for integration and communication between the individual modules, user-friendly software updates, opportunities for easy integration of future software extensions, creation of dynamic analyses and reports on the data provided by all institutions. In this way, HEIs can use Quality Assurance in Higher Education as a Service (Hadzhikoleva et al., 2016b).
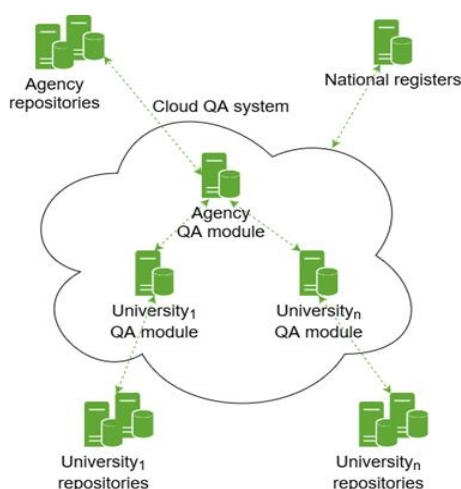
Figure 3. Centralized accreditation model

While in the weakly centralized model there are non-automated connections and processes, the highly centralized model not only removes many of the connections between various unstable components in the software environment, but also creates greater opportunities for automation of the quality assurance and accreditation processes.

The main functionalities in the modules of the agency and the higher education institutions in the highly cen-tralized model are presented in Table 1. Many of them have been successfully experimented in the COMPASS system.

Table 1. Main functionalities and their management in a highly centralized model

Functionality	Description	Accr. Agency	HEI
Meta-meta-model of assessment methodology	Modeling the main types of assessment components of the assessment methodology and possible connections between them.	✓	✗
Meta-model of assessment methodology	Creating a data model for each type of assessment component and the possible actions (functionalities) on it.	✓	✗
Model of assessment methodology	Creating a hierarchical model of assessment methodology.	✓	✗
Model of procedure for	Indication of the methodology used for a specific type of assessment. Determining basic	✓	✗

self-assessment / assessment based on methodology	parameters on an assessment procedure: setting start and end dates, roles, access rights to the activities, etc. Specific procedures based on methodology can be for: self-assessment by the HEI, assessment by an expert group, accreditation, etc.		
Starting a procedure	Determining values of parameters necessary for staring the procedure by the NEAA: users with administrative rights under the relevant procedures, deadlines, etc.	✓	✗
Procedure administration	Configuration of users and additional parameters by administrators of: • The HEI (in the case of self-assessment); • Expert group (in case of assessment by an expert group); • Accreditation agency (in case of accreditation).	✓	✓
Execution of a procedure	Entering data for a specific assessment procedure by authorized users.	✓	✓
Completion of a procedure	Hierarchical, step-by-step completion of the procedure.	✓	✓
Modeling of automated assessments, analyzes, reports, etc.	Creating standardized reports to help participants in assessment procedures. Creation of functions for automated assessment of assessment elements, methodologies or their sub-components, based on mathematical methods and functions. Creating functions for analysis and comparison between all or selected higher education institutions, using statistical methods and AI methods.	✓	✗

6. GN model of data processing of self-assessment in the higher education institution

The Generalized Net (GN) apparatus is a powerful tool for modeling time-parallel processes, applied in various fields and fields of application (Atanassov, 1991; Atanassov, 2007). We used GN notation successfully to formalize different QA processes and systems (Hadzhikoleva et al., 2019; Hadzhikoleva et al., 2020).

The GN, describing data processing of self-assessment procedure in the higher education institution contains the following set of transitions:

$A = \{Z_1, Z_2, Z_3, Z_4\}$, where:

Z_1 – Data collection from various data sources;

Z_2 – Data integration;

Z_3 – Data processing on the requirements, related to the criteria system;

Z_4 – Preparation of self-assessment report and relevant applications.

The following tokens are used to describe the processes:

- α-token – data on the activity of the higher education institution;

- β-token – members of the administrative and academic staff, members of the quality committee and the self-assessment report preparation group;

- μ-token – criteria system of the accrediting institution;

- η-token – Data repository with up-to-date information on the activities of the higher education institution, necessary for the preparation of a self-assessment report;

- γ-token – Data processing tool;

- σ-token – Data request from an user/application.

The Generalized Net model is presented in figure 4.

Transition 1: Data-collection from various data sources.
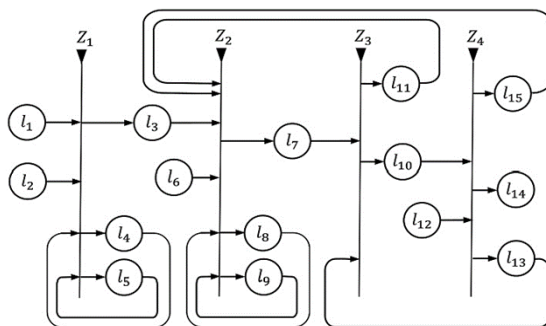
Figure 4. GN model of data processing of self-assessment procedure in HEI

The information is collected by various administrative and educational units. In some cases, there are no established standards and often the same type of information is structured differently by the different units. Some of the information is processed manually, whereby updating already processed information requires re-processing and summarizing. If the educational institution does not have a unified repository of administrative and educational documents, there is the risk of providing duplicate information, using outdated data and documents, etc.

The process is started when α-token enters the generalized net from position l_1, with initial characteristic: *"ID data (set of data), value"*.

Through position l_2, new members of the administrative and academic staff can come through β-tokens, with initial characteristic: *"ID, user name"*. In position l_4 stands α-token with characteristic: *"higher education institution environment data store"*.

In position l_5 stands β-token with feature: "*users - members of the administrative and academic staff*".

The users - members of the administrative and academic staff are with different competencies participate in the evaluation procedures. They are from different units, have different rights and responsibilities, different access to information, different opinions and vision of the quality of education, teamwork skills, etc.

During the activation of transition Z_1, the α-token of position l_5 is split into two tokens. One remains in position l_5 and the other token merges with a-token from position l_1 and enters position l_3 gaining a characteristic:

"*ID data, ID user, value*".

$Z_1 = <\{\ l_1,\ l_2,\ l_4,\ l_5\},\ \{l_3,\ l_4,\ l_5\},\ r_1>,$

$$r_1 = \quad \begin{array}{c|ccc} & l_3 & l_4 & l_5 \\ \hline l_1 & W_{1,3} & true & false \\ l_2 & false & false & W_{2,5} \\ l_4 & W_{4,3} & true & false \\ L_5 & false & false & true \end{array}$$

$W_{1,3} =$ *"*new data (a set of data) has arrived from the environment*"*;

$W_{2,5} =$ *"*a new user (member of the administrative/academic staff) has arrived*"*;

$W_{4,3} =$ *"*a new data (set of data) proceeds to Data repository*"*.

Transition 2: Data integration in Data repository.

During the activation of the Z_2 transition, a μ-token enters through position l_6 with characteristic: *"criteria system of the accrediting institution"*.

The a-token from position l_3 merges with μ-token from position l_6 and enters position l_7 receiving a characteristic: *"ID data, ID user, type of processing"*.

In position l_8 cycles η-token with characteristic:

"*Data repository with up-to-date information on the activities of the higher education institution, necessary for the preparation of a self-assessment report*".

A data repository can have a different structure and type of data stored.

Various applications are usually used in practice which partially automate different quality assurance activities. They automatically retrieve the necessary accreditation data from the university repositories (students and learning, curricula and programs, human resource management, document repository, scientific achievements, publications, projects, etc.).

This tool can perform pre-processing of the received data, as well as the necessary format transformations, and subsequently, these data are integrated into Data repository. For this purpose, in position l_9 cycles γ-token with characteristic:

"*Data processing tools*".

$Z_2 = <\{\, l_3, l_6, l_8, l_9, l_{11}, l_{15}\}, \{l_7, l_8, l_9\}, r_2>,$

$$
r_2 =
\begin{array}{c|ccc}
 & l_7 & l_8 & l_9 \\
\hline
l_3 & false & W_{3,8} & W_{3,9} \\
l_6 & true & false & true \\
l_8 & W_{8,7} & true & false \\
l_9 & W_{9,7} & false & true \\
l_{11} & false & W_{11,8} & W_{11,9} \\
l_{15} & false & W_{11,8} & W_{15,9}
\end{array}
$$

$W_{3,8} =$ "data has arrived in the repositiry";

$W_{3,9} =$ "data processing was performed by a tool";

$W_{8,7} =$ "a data (group of data) has been retrieved from the repository";

$W_{9,7} = W_{3,9}$;

$W_{11,8} =$ "new data has arrived as a result of Data analytical processing";

$W_{15,8} =$ "a request has been received for data from the repository";

$W_{11,9} =$ "a data processing tool is implemented";

$W_{15,9} = W_{11,9}$.

Transition 3: Data processing, on the requirements related to the criteria system. For the preparation of the main document – the self-assessment report, it is necessary to collect a large amount of diverse information and documents, and to prepare a variety of reports. This includes, for example, reports on the structure of the academic staff, participation in scientific and educational forums, number of international scientific contracts, information on successful PhD students, number of publications and citations of the academic staff, publications abroad and of international forums, publications in peer-reviewed scientific journals, etc.

During activation of transition Z_3 a-token enters position l_{10} or position l_{11} receiving a characteristic: *"ID data (set of data), applied analysis tool"*.

$Z_3 = <\{\, l_7, l_{13}\}, \{l_{10}, l_{11}\}, r_{13}>,$

$$r_3 = \begin{array}{c|cc} & l_{10} & l_{11} \\ \hline l_7 & W_{7,10} & W_{7,11} \\ l_{13} & false & W_{13,11} \end{array}$$

$W_{7,10} = $ *"the data analytics process has not completed"*;

$W_{7,11} = $ *"the process for analytical processing of the data is completed"*;

$W_{13,11} = W_{7,11}$.

Transition 4: Preparation of a self-assessment report and the relevant applications, based on the data from the repository.

During the activation of the transition Z_4, a σ-token enters through the access l_{12} with a characteristic: *"data request from user/application"*,

An α-token from position l_{10} merges with a σ-token from position l_{12} and enters position l_{13}, l_{14} or l_{15} receiving a characteristic respectively:

"ID user, request for analytical processing";

"ID user, data (set of data), included in the self-assessment report";

"ID user, request data from the repository".

$Z_4 = <\{ l_{10}, l_{12}\}, \{l_{13}, l_{14}, l_{15}\}, r_4>$,

$$r_4 = \begin{array}{c|ccc} & l_{13} & l_{14} & l_{15} \\ \hline l_{10} & W_{10,13} & W_{10,14} & W_{10,15} \\ l_{12} & true & true & false \end{array}$$

$W_{10,13} = $ *"execution of an analytical processing request is required"*;

$W_{10,14} = $ *"requested data has been included in the assessment report"*;

$W_{10,15} = $ *"a request for data from the repository is required"*.

A formal model is proposed here, describing data processing of self-assessment in the higher education institution. Many refinements can be made by using a hierarchical operator (H3 of the GN theory) that replaces a given transition or position with a sub net that has the same but described more detailed behavior of the elements. Based on the created GN model and the collected data from real processes, behavioral patterns and performance analysis of various system components can be detected.

7. Conclusions

A major challenge for accreditation institutions is to provide an opportunity for commensurability of the evaluation of the quality of educational services offered by higher education institutions. This paper proposes two models for quality assurance in the higher education area – highly and weakly centralized, and a formal model of data processing for self-assessment procedures in HEIs.

The main goal of the first two models is to propose a platform that facilitates the work of all participants in the evaluation and accreditation procedures both on the educators' side and on the accrediting institutions' side. They provide an opportunity to automate the processes related to the various stages of the accreditation procedures. The use of software systems based on the proposed models has many advantages – centralization of the assessment processes, which facilitates their administration and monitoring; providing a common platform for asynchronous team work of users with different rights and responsibilities; ability to work at any time and from any place, facilitated communication and transparency; automated generation of documentation; optimization of time and material resources; reducing the likelihood of making mistakes, etc. The weakly centralized model provides a greater opportunity for integration of the university QA system with other internal systems of the institution and its own control over business data. The main disadvantages are the need for additional IT specialists to maintain and upgrade the QA system, as well as duplication of a large amount of information in the centralized module of the agency. The highly centralized model is easier to use by the higher education institutions, it minimizes the need for administrative support by the HEI, eliminates the need for duplication of information but complicates the possibilities for its integration with existing university systems.

The proposed GN model aims to formalize the main steps and activities in the collection, storage, processing, and distribution of the data from various sources, necessary for self-assessment in the higher education institution. The proposed model can be used as a basic framework and can be expanded on, by further developments and improvements.

Acknowledgment

REFERENCES

Atanassov K. (1991) Generalized Nets. *World Scientific*, Singapore.

Atanassov K. (2007) *On Generalized Nets theory*. Prof. Marin Drinov Publishing House, Sofia, ISBN: 978-954-322-237-7.

Hadzhikolev, E. & Hadzhikoleva, S. (2016) Model for Automated Integration of Data from Heterogeneous Sources in the COMPASS-OK Application for (Self)

Evaluation and Accreditation. *International Journal of Applied Engineering Research*, 11(12), 7648-7653.

Hadzhikoleva, S. & Hadzhikolev, E. (2016) The COMPASS-OK Model for Quality Assurance in Higher Education. *International Journal of Applied Engineering Research*. 11(11), 7326-7332.

Hadzhikoleva, S. & Hadzhikolev, E. (2016) QAHEaaS or Quality Assurance in Higher Education as a Service. *Tem Journal*. 5(3), 363-370.

Hadzhikoleva, S., Orozova, D., Andonov, N. & Hadzhikolev, E. (2019) Generalized Net Model of a System for Quality Assurance in Higher Education. In *AIP Conference Proceedings 2172*. 040005. doi: 10.1063/1.5133515.

Hadzhikoleva, S., Orozova, D., Hadzhikolev, E. & Andonov, N. (2020) Model of a Centralized System for Quality Assurance in Higher Education. *Proceedings of 10th International Conference on Intelligent Systems*. pp. 87-92.

Higher Education Act (2015) *State Gazette*, issue 112 of 27.12.1995.

Institutional accreditation of higher schools. *National Evaluation and Accreditation Agency.* https://www.neaa.government.bg/en/evaluation-and-accreditation/institutional-accreditation. [Accessed 27th July 2023].

National Education Systems. Eurydice Network, Publ. Education. *Audiovisual and Culture Executive Agency Platform.* https://eurydice.eacea.ec. europa.eu/national-education-systems. [Accessed 27th July 2023].

Standards and Guidelines for Quality Assurance in the European Higher Education Area (ESG) (2015) Brussels, Belgium. ISBN: 978-9-08-168672-3, https://enqa.eu/wp-content/uploads/2015/11/ESG_2015.pdf.