Methodology for Constructing Academic Programs Using Computer Support Systems

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Abstract: The process of developing academic programs is labor-intensive and complex. High-level intellectual ability is required from the program's developer.
The purpose of the document is development of such methodology and relevant model of academic program construction that would allow for the distribution of the problems related to the program creation between the program creator and the expert system.
To that end, a panel of specialists conducts preliminary work to design the framework of the academic program amid of expanded program requirements for the specific study fields and those set by them.
On the basis of an academic program framework, several academic programs of the same qualification can be developed.
Based on the potential of the suggested model, an opinion has been expressed on the possibility of constructing a computer system for the development and evaluation of academic programs.

Keywords: academic program, academic program construction methodology, automated computer support systems for academic program construction, academic program evaluation.

1. Introduction

This work aims to provide a model that ensures impartiality, program and evaluation quality improvement, and simplification of the academic program development process.

As the extensive experience of creation of academic programs shows, there are four processes distinguished within the process of creation and accreditation of academic programs:

- Business process of academic program creation and accreditation;
- Process of academic program and syllabi construction;
- Process of academic program evaluation;
- Process of formation of the academic program self-evaluation report.

The business process of academic program creation and accreditation includes the stages of program creation and accreditation, as well as their sequence having been defined by the state standards and normative documents of the (e.g. documentation of the National Center for Educational Quality Enhancement [1]) and the normative acts issued by the institution.

Therefore, these processes are typical business processes and we are not going to discuss them further in this document.

The process of construction of the academic program and syllabi, apart from being based on certain business processes, standards and normative documents [1], is mainly a creative process performed by the head of the program and the self-evaluation group. The produced program and syllabi shall reflect the vision of the head of the program regarding teaching of the specific study field.

Consequently, the above defines course graduates' success on the labor market, their competitiveness and motivation.

Despite the fact that the program head has a working group, which actively interferes into the decision-making process, the academic program is still a product of creativity of the program head.

The institution is required by the standards to establish a set of target benchmarks for particular directions based on the gathering, generation, and analysis of information. It is the institution's sole responsibility to produce reliable information and set the benchmarks when proper methodologies and benchmarks are lacking at the national level.

Internationalization of higher education, which also include internationalization of the processes and quality assurance systems, poses a significant challenge. It should also be highlighted that international specialists are involved in the accreditation process and internal university evaluations, which, in most cases, entails additional costs (both for the institution and the state).

Respectively, several significant problems are identified within the process of creation, development and accreditation of academic programs:

- Complexity of academic program creation;
- Achievement of high quality of the program;
- Achievement of high quality of academic program evaluation.

2. Existing Technologies for Automated Construction of Academic Programs

The management of the educational process, including the challenges surrounding the development of academic programs, is a topic that appears in many scholarly works. Many academic program development-related studies defining the framework for program creation have been done.

There are also certain automated program creation methodologies and associated information systems, which partially cover the process of program construction and primarily serve the needs and activities of a single user - the head of the academic program. These systems are not designed for administration of the processes related to program construction.

There is CASCADE-SEA [2–4] computer support system for the academic process one of the functionalities of which is creation of academic programs. Evaluation of the quality of the academic program in the system is performed by an expert. The system is efficient in terms of academic program creation, but it does not allow for automation of the procedures of preparation of academic programs for external evaluation/accreditation and evaluation of academic program quality.

Another computer system which is also interesting is CASCADE-MUCH [5], which is intended for the development of multimedia academic programs. Within this system too, academic program quality is evaluated by an expert. Analysis of this system allows us to conclude, that the system of academic program construction can be based upon the framework defining the specifics of the field of knowledge.

There are two groups of patents, one of which is aimed at simplifying intellectual labor of the program head, while the second group is aimed at educational program evaluation. Therefore, these approaches separate from one another the two above problems and do not allow for presenting the process of creation and evaluation of an academic program within a single perspective.

For example, patents [6,7] ensure automated creation of educational programs, but do not take into consideration the regulations for development of educational programs existing within the institution. Also, the subject is given full freedom in terms of conceptual development of the program. This, in turn, requires a high qualification of the subject developing the program.

These patents have been in effect for quite some time. As a result, the reality for institutions of higher education has altered. Since education is growing more expensive and public funding is decreasing, there has been a desire and matching tendency on a global level for universities to operate like modern enterprises for years. Annual growth in the need for higher education and the importance of reporting, among other things, go hand in hand with an

increase in personal benefits [8]. As a result, colleges should start implementing novel strategies in their core business, including cutting-edge technologies for effective management of intricate and complex procedures.

A review of numerous publications reveals that while some of the stated models and systems do meet the criteria for the development of academic programs, others do not. Additionally, because these systems do not take into account the participation (rights, obligations) of hierarchical structures of higher education institutions (program heads, academic departments, faculty quality assurance unit, faculty board, university quality management unit, academic board) in the process of academic program formation and a sequence, it is impossible to manage the adaptation of these systems in order to use them for the formation of academic programs of higher education institutions.

Publication [9] emphasizes the necessity of applying quantitative indicators of expert evaluation of the academic program.

For this purpose, criteria characteristic of the program's strengths and weaknesses are developed, to which score points are assigned. Overall evaluation of the program is also expressed in numerical rating.

The systems under discussion envisage the creation of academic curricula for various levels of education, which, for institutions of higher education, may include courses in vocational education, BA, MA, and PhD programs. Systems give subjects creating academic programs complete conceptual flexibility for each educational level (of course, the regulations and standards already in place for the program shall be respected).

This, in turn, requires high qualification of the subject developing the program. These systems also envisage, to a certain extent, the requirements (standards) existing regarding academic programs, which have to be taken into account by the program head. However, they do not envisage a conceptual structure of a program formation.

It is expedient for institutions of higher education to provide a conceptual framework for the creation of academic programs at each level of education in a variety of scientific disciplines. For instance, the conceptual framework of an academic program could be of one type in the field of engineering and of another type in the field of architecture, etc. Additionally, there are no pre-established templates of conceptual structures for the creation of educational courses (syllabi) in the current system.

3. Methodology for Academic Program Construction

The proposed methodology differs from the above methods and systems and enables the following:

- Automated implementation of the academic program according to the business process developed by the institution, which also takes into consideration the state standards of accreditation and requirements of the institution;
- Program evaluation during and after the process of implementation, also including evaluation by the accreditation body.

Unlike the existing systems, the proposed one is universal in terms of reflecting various fields of knowledge, since it envisages application of the academic program framework for every field of knowledge. The evaluation component of the program defines a list of the program's strengths and weaknesses, which are evaluated by experts, among them evaluation based on quantitative indicators.

Evaluation of state accreditation standards of the academic program, as well as general evaluation of the program are automatically performed by the system and expressed in qualitative indicators, which are based on AI methods.

The proposed technology enables the following:

- To define on the institutional level the conceptual structural frameworks of the program's curriculum and syllabi taking into account the requirements set for the program and consequently to provide significant assistance to the program head in the activities;

- To define the framework of the business process of program creation on the institutional level and, based on it develop the business process of program creation, with participation of all the structural or organizational units involved in it;
- To describe the accreditation standard requirements, using the criteria describing the program's strengths and weaknesses and to transform the qualitative indicators of the evaluation of accreditation standards into corresponding quantitative criteria;
- To support the expert qualitative evaluations of the academic program in the process of internal institutional evaluation and accreditation with expert quantitative evaluations. The decision about evaluation is made utilizing AI tools.

Proposed methodology of academic program construction applies a typical framework for program creation, as well as during evaluation for specific fields of knowledge. The framework describes the conceptual structure of the academic program's curriculum and syllabi, as well as the business processes of the program development, taking into account the accreditation standards as well as the requirements established by the institution, and includes the AI tool for program evaluation.

4. Academic Program Construction and Evaluation Model

This work aims to provide a model that ensures impartiality, program and evaluation quality improvement, and simplification of the academic program development process.

As was just mentioned, there are numerous computer support systems for streamlining the activities of the academic program head, but since this component is decided by the program head, they cannot provide mandatory and guaranteed compliance with the regulations existing regarding the academic program.

An innovative approach is suggested to address this issue, as well as to simplify the work of the program head and enhance the program's quality. In this approach, the computer system that supports the development and evaluation of academic programs will be responsible for ensuring mandatory compliance of the program's requirements.

The methodology of the substance of functioning of the computer system that provides support to the academic program construction and evaluation processes, is as follows:

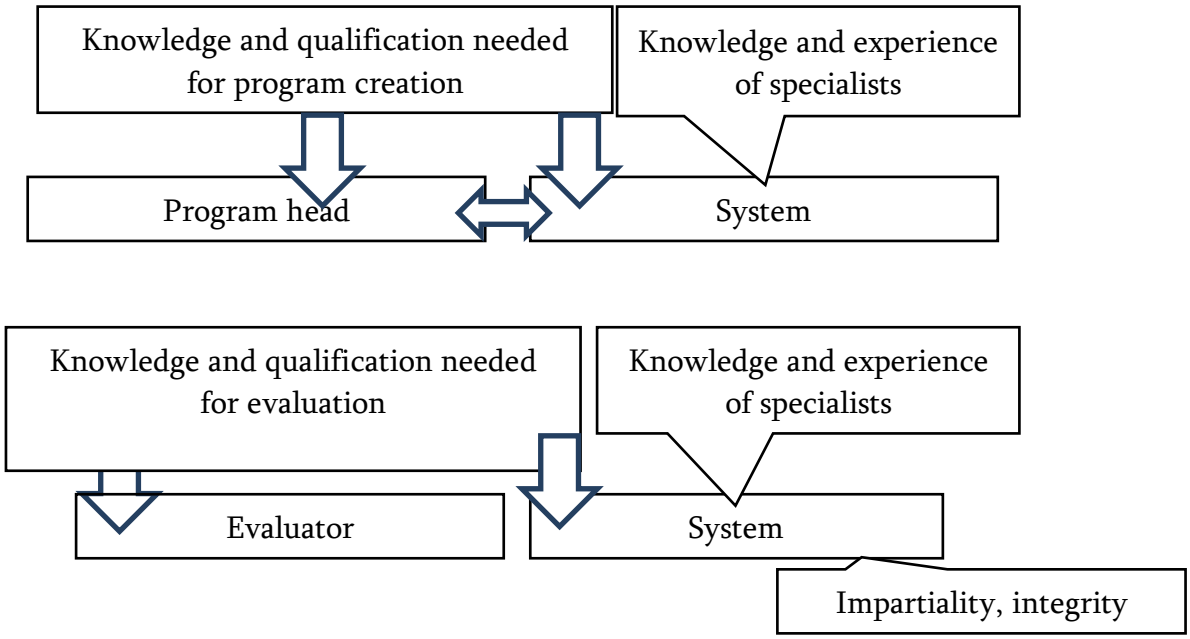
Let us assume that in order to create a program, the academic program head performs the following actions/functions $F_{head} = \{f_1, f_2, \dots, f_n\}$.

Let us also assume that during external evaluation, as well as in the process of accreditation the following actions/functions are performed $G_{evaluation} = \{g_1, g_2, \dots, g_m\}$.

Every action/function also implies making of a decision within the frames of the given action.

The substance of the proposed methodology is to distribute the multiple functions $\{f_1, f_2, \dots, f_n\}$ and $\{g_1, g_2, \dots, g_m\}$ among the program head, the evaluation committee and the computer system (Figure 1).

We can say intuitively, that the more functions are covered by the computer system, the lesser will be the number of functions assigned to individuals characterized with subjective attitude.



Systemic Approach to Educational Program Creation

Figure 1. Systemic approach towards academic program creation

There is another advantage to such a strategy. The cumulative expertise and experience of specialists found in the computer system should be of a higher caliber than of the program head's when it comes to making decisions.

For the moment of academic program creation, the program head is aware of the following:

- Academic program standards;
- Sectoral specificities;
- Institutional requirements and relevant normative documents.

All of these requirements form a wide set of total requirements

$$V_{total} = V_{standard} \cup V_{field} \cup V_{institution},$$

which must be fulfilled by the program head.

It should be noted, that the requirements $V_{institution}$ comply with the conditions of the requirements $V_{standard} \cup V_{field}$ meaning that the institution is always obliged to meet these requirements.

In addition, at the initial stage of program construction, the program head formulates a set of own requirements $V_{additional}$, the number and content of which do not change at the next stage of construction. The set of $V_{additional}$ complies with the conditions of the requirements of V_{total}.

The set $V_{additional}$ may include strategic visions of program construction related to structure, content, teaching forms, etc. such as:

- Types of disciplines in the academic program curriculum;
- Credits of disciplines of the academic program curricula;
- Compilation and arrangement of disciplines within the academic program curriculum;

- BA draft or paper in the academic program curriculum;
- Group projects within the academic courses;
- Total volume of free components;
- Etc.

Therefore, additional requirements $V_{additional}$ regarding the academic program, along with the requirements V_{total} , form a kind of an outline draft of the academic program, which has to be transformed by the program head into a detailed draft.

Since based on the requirements of this outline draft

$$V_{program} = V_{total} \cup V_{additional}$$

Within the framework of the qualification to be awarded, it is possible to create multiple academic programs we decided to call $V_{program}$ the framework of the academic program.

Schematically we can imagine the academic program framework as follows (Figure 2).

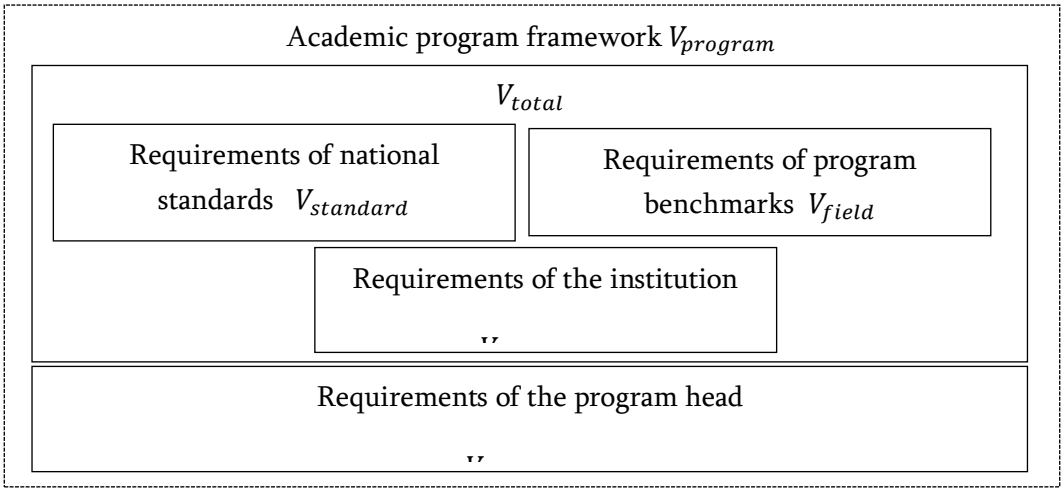


Figure 2. Academic program framework structure

In general, expert method is applied to evaluate the quality of an academic program through determining compliance of the program with the state standards.

The existing evaluation method is qualitative and not quantitative.

Consequently, the existing method of evaluation is subjective and has a large error margin.

Let us assume that the process of academic program development consists of consecutive actions $F_{head} = \{f_1, f_2, \dots, f_n\} G_{evaluation} = \{g_1, g_2, \dots, g_m\}$: intellectual processes, evaluation processes, and business processes where n number of actions in the process of academic program design is performed by the program head.

Let us also presume, that the probability of smooth performance of one action is $P_i^{head} = 0{,}5, i = \overline{1, n}$.

Consequently, the probability of smooth construction of the academic program will be $P_{program} = \prod_1^n P_i$.

Now, let us assume that $n = \overline{(1, k)} + \overline{(k+1, n)}$, where k actions are performed within the academic program framework (for example, within the curriculum framework) developed by a group of specialists).

If we assume that m is the number of specialists. The probability of smooth implementation of one action by one specialist, as in the case of the program head, is $P_j^{specialist} = 0,5,\ j = \overline{1,m}$. Specialists work on the framework as a team (in parallel mode).

Consequently, the probability that one action needed for the development of the framework will be implemented seamlessly and without any error is:

$$P_{framework} = 1 - \prod_{j=1}^{m}(1 - P_j).$$

If we assume, that $m = 3$ specialists working on creation of the framework, then

$$P_{framework} = 1 - \prod_{j=1}^{m}(1 - P_j) = 1 - 0,125 = 0,875$$

Therefore, the probability of conducting one faultless action to create the framework equals to $0,875$, which, in turn, is higher than the probability of faultless performance of the same action by the program head.

In case of action k, the probability of smooth creation of the framework will be

$$P_{framework} = k(1 - \prod_{j=1}^{m}(1 - P_j)) = k * 0,875,$$

while the probability of smooth performance of the same action by the program head would be $k * 0,5$.

Therefore, application of a framework in the process of academic program construction increases the probability of its smooth implementation.

5. Automated system of Academic Program Construction and Evaluation

The main component of the proposed model is the computer support system, which will integrate all the functional or decision-making blocks of all the subjects, structural units and internal or external expert groups of the whole university involved in the process of academic program construction and evaluation.

Consequently, the computer support system for academic program construction includes the following:

Database of academic program frameworks (there may exist several frameworks for the same level of education depending on the specifics of the qualification to be awarded);

- Database of syllabi frameworks;
- Database of the requirements (criteria) set for the academic programs;
- Database of academic programs.

Respectively, there are the following subsystems:

- Subsystem of the university quality assurance unit;
- Subsystem of the faculty quality assurance unit;
- Subsystem of the academic department (syllabus author uses the subsystem of the academic department);
- Subsystem of the program head;
- Subsystem of the syllabus author;
- Subsystem of system administration.

Subsystem of the university quality assurance unit:

- Formation of the syllabi and academic program frameworks;
- Academic program status management;

- Independent evaluation of completed academic programs;
- Discussion of programs before presenting them to the faculty board and permit issuance.

Subsystem of the faculty quality assurance unit:

- Program head status management;
- Syllabus author status management;
- Receiving a program from the program head;
- Submitting programs to the quality assurance unit for consideration;
- Submitting programs to the faculty board;
- Uploading of faculty board decisions and submitting programs to the university quality assurance unit.

Subsystem of the academic department:

- Placement of syllabi and their abstracts in the system;
- Management of syllabi statuses;
- Issuance of permits on use of syllabi to program heads;

Subsystem of the program head:

- Program formation/modification;
- Uploading of conformation documents;
- Program evaluation;
- Submitting of a program to the faculty quality assurance unit;

Subsystem of the syllabus author:

- Syllabus formation/modification;

Subsystem of administration:

- Management of statuses of users of the university quality assurance unit;
- Management of statuses of users of the faculty quality assurance unit.

The purpose of the administration subsystem is management of user access and management of general data of the syllabi and academic programs.

The establishment of initial program frameworks and syllabi for academic programs at specific levels of education (for instance, engineering) as well as the management of framework statuses (active, to be edited, blocked, etc.) are the goals of the subsystem of academic programs and syllabi frameworks.

The construction of specific academic course syllabi in accordance with the framework's specifications is the goal of the syllabi subsystem. The academic department creates syllabi and controls their statuses (active, to be modified, blocked, etc.). Syllabi are controlled by this department.

The construction of academic programs by the head while adhering to the framework standards is the goal of the subsystem of academic programs. The faculty is the owner of academic programs, and it controls program head profiles and statuses (such as active, to be modified, blocked, etc.).

System profiles:

- University quality assurance unit (setting the requirements, creation of syllabi and program frameworks and their status management);
- Faculty quality assurance unit (program head profile management, management of the stages of program

review, management of the academic department profile);
- Academic department (management of own syllabi);
- Program head (introduction of new programs, modification and evaluation of programs).

6. Conclusions

- The model and methods for developing academic programs are suggested, and they call for using the framework for building particular academic programs.
- Academic program framework implies that state standards, program standards, sectoral standards and strict requirements made by institution and specialists about programs in particular domains of knowledge must all be integrated and cannot be changed by the program head.
- There is enough evidence provided to state that distribution of of the field of tasks by experts for academic program creation between the predetermined academic program framework and the program creator reduces the probability of seamless implementation of the program.
- The proposed methodology for developing an academic program increases the likelihood that the process of creating academic programs will be automated since it decreases the amount of intellectual labor required of the program author.
- A general COMPUTER support system architecture for the development of academic programs is offered.

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