Quality of education as the modeling object: "black", "white" or "gray" box for national economics development

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Abstract. The article describes the dynamic "quality of education" system as an object of modeling with initial data, system parameters, control parameters, disturbing parameters and output parameters. Drawing analogies in the description of a dynamic system as applied to intangible objects allows obtaining a detailed description of the factors regarding the internal and external influence on a dynamic system and predicting the reaction of this system to a change in the elements of power. When describing the quality of education system, one should consider the relationship between its socio-economic impact and the following properties: purposefulness of the system; system hierarchy; interdependence between the system and the external environment; the level of autonomy and openness; system reliability; dimension of the system. Based on the data on the description of the methods of black, gray and white boxes, an algorithm for the transition between models for the quality of education system was formed. The description of the system is carried out by moving from the black to the gray box model, and then to the white box. Each of the models can be self-sufficient and satisfactorily describe a set of input and output parameters. However, the degree of determinism of the description process increases with the transition from the previous model to the next.

Keywords: quality of education, socio-economic impact, box model, black box, gray box, white box

1. Introduction

When describing material systems in engineering, physics and other sciences, the definition of "technical system" has found application – a system whose functioning can change its characteristics over time depending on external parameters, control parameters and other factors. This system must have a purpose and perform a particular set of functions. The

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description of the functioning of such systems is reduced to a set of mathematical formulas (mathematical model), which in some cases is supplemented by the results of experimental studies. Such a system can be deterministic in the absence of disturbing external influences that do not have a pattern of occurrence. The use of the term technical system to describe intangible objects has its drawbacks: the laws of describing such things can be subjective and stochastic, and the number of disturbing influences is significant. However, drawing analogies in the description of a dynamic system as applied to non-material objects allows one to obtain a detailed description of internal and external influence on a dynamic system and predict the reaction of this system to changes in the elements of power. This approach can be quite effective in describing the functioning of the dynamic system of education quality. At the same time, various approaches to the study of causal relationships can be applied to the dynamic quality of education system, which differ in the degree of openness of the initial data, system parameters, control parameters, disturbing factors and output parameters. Such approaches are in the theory of testing technical systems and software products. Such approaches in the theory of testing technical systems and software products are called black, gray and white boxes.

When describing the quality of education system, one should consider the relationship between its socio-economic impact and the following properties:

- the purposefulness of the system;
- system hierarchy;
- the interdependence between the system and the external environment;
- the level of autonomy and openness;
- system reliability;
- system dimension.

The work aims to analyze the system of quality of education as black, gray and white boxes with the analogy between physical (engineering) and non-material systems. In this case, it is mandatory to assess the impact of the design on the socio-economic development of an organization, territory, country, etc.

2. Literature review

The approach to describing dynamical systems in the form of a black, gray or white box is inherent not only in technical engineering or computer systems. Such approaches have already found application in cybernetics, economics and other branches of knowledge [1, 8, 10, 12, 14–16, 23, 28, 29, 32]. The boxes method has also been applied in the educational sphere, but not for describing management (control) processes, but for specific applications in the educational process (training) [26]. While testing the "quality of education" system, one should also consider innovations in the educational sphere [13, 17, 19, 20, 24–27] and the trend of ensuring the goals of sustainable development in education [4, 7, 9, 18, 21, 30, 31].

Bibliometric analysis of literary sources published in journals from the scientometric Scopus database (figures 1, 2, VOSviewer bibliometric analysis tool) has shown an increase in interest in introducing an approach to describing intangible systems by analogy with technical systems.
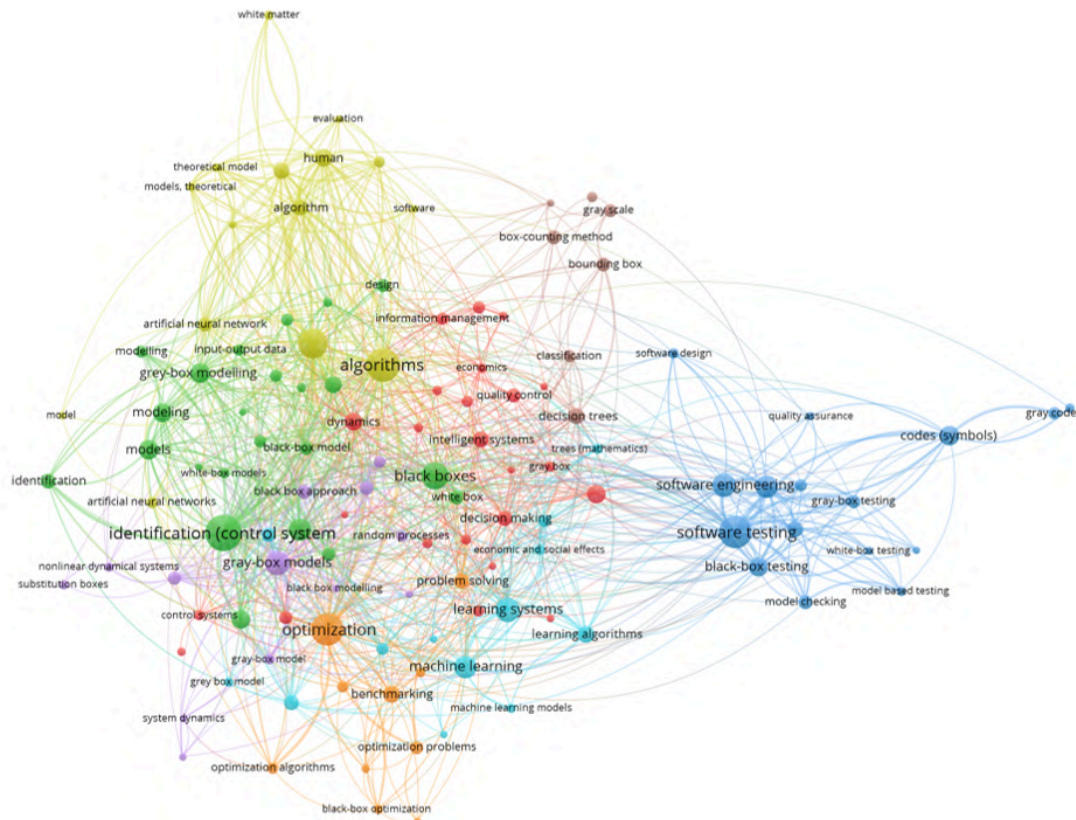
Figure 1: Bibliometric analysis on request "technical system".

Besides, the relationship between the keywords black box, gray box, white box, economics and quality assurance is noted. However, the term quality assurance does not refer to education, but to software testing. The "unit testing – quality control – quality assurance" approach can be successfully used to establish a causal relationship between the education quality and the country's socio-economic development. At the same time, it is important to clearly define the conditions for the existence of the education system quality from the point of view of inputting initial data and predicting the obtained results.

3. Research methodology

An algorithm for the transition between models of the education system quality was formed based on the data on the description of the methods of black, gray and white boxes [2, 11, 22]. The algorithm is shown in figure 3.

The system is described by moving from the black box model to the gray box model, and then to the white box model. Each of the models can be self-sufficient and satisfactorily describe a set of input and output parameters. However, the degree of determinism of the description process increases with the transition from the previous model to the next.

Figure 2: Bibliometric analysis on request "gray box": relationship with "black box", "white box" by other keywords.

4. Results

This section describes the relationship between some input parameters of the system "quality of education" and the output indicators of the system "quality of education", affecting the economic growth of the university and the region.

Output parameters Y:

1. Rating of the university educational program among employers.
2. Average salary of an educational program graduate of.
3. Career growth of the educational program graduate.

Input parameters X:

1. The list of educational programs.
2. The presence / absence of students' training at the expense of state funding.
3. Cost of training.
4. The competitors in the region.
5. Base of practice.
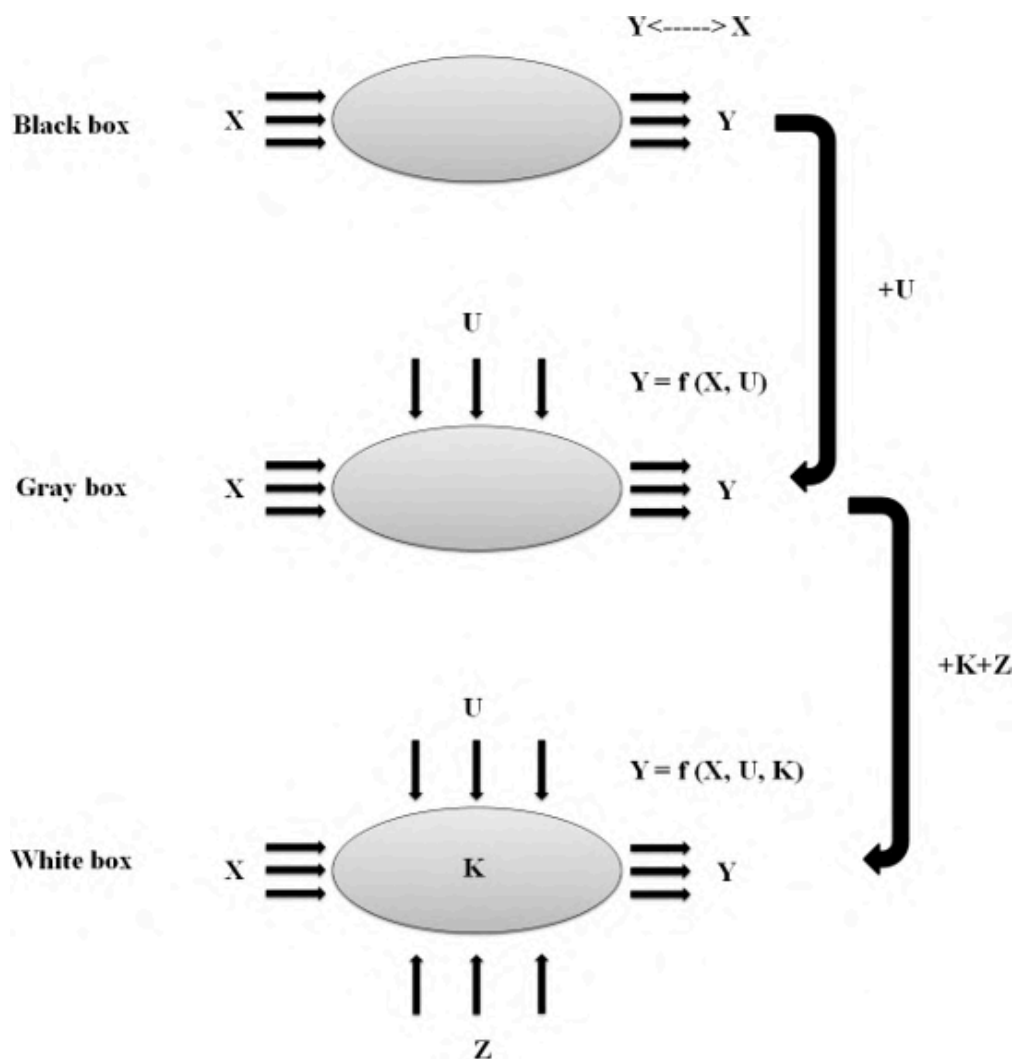
Figure 3: Box model for describing the quality of education system: X – input parameters; U – control parameters; K – system parameters; Z – disturbing parameters; Y – input parameters.

  6. List of potential employers.

The parameters of the K system can be presented as features of the educational program and the educational environment in comparison with similar programs (benchmarking of educational programs) (figure 4) or according to the comparative data of rating agencies (figure 5).

Parameters of control U – can be represented via radial diagram with an assessment of the influence degree on the output parameter on a scale from 1 to 10 points (figure 6).

Disturbing parameters Z:

  1. Changes in the policy of the Ministry of Education and Science of Ukraine, including the financing of the general fund of the university based on its educational, international and scientific activity results.
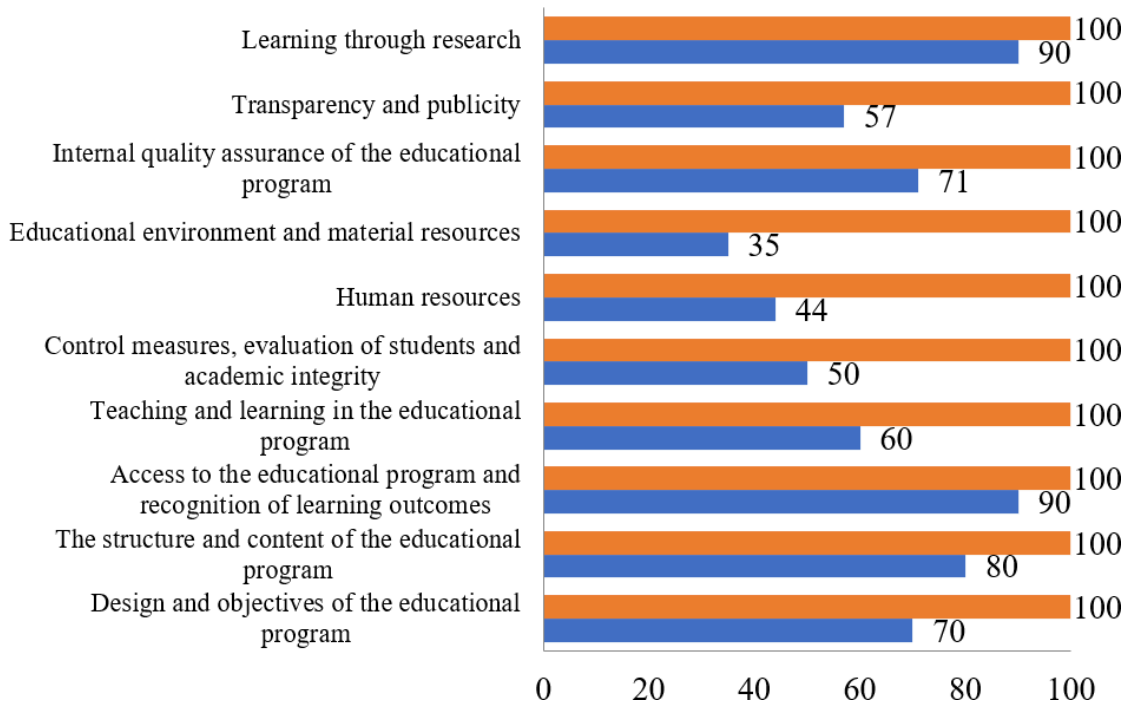
Figure 4: Description of the educational program and educational environment (benchmarking of educational programs, visualization, random data).

2. The impact of military activities in the temporarily occupied territories on the state economy.

5. Conclusions

The proposed algorithm for the sequential description of the "quality of education" system and its socio-economic impact enables to:

1. Establish a clear list of indicators regarding the influence of input, control, and system parameters on output parameters predicting their change.
2. Develop mechanisms affecting the system through control parameters to increase the value of the output parameters.
3. Assess the state of the system parameters and determine how to improve them.
4. Predict the state of the system when disturbing influences are imposed on it.
5. Create a roadmap for the required output parameter at the operational (situational), tactical and strategic levels.

"Box" modeling makes it possible to predict the behavior of the dynamic system "quality of education" at various stages of its life cycle:

1. While testing the null hypothesis – based on the "black" box model.
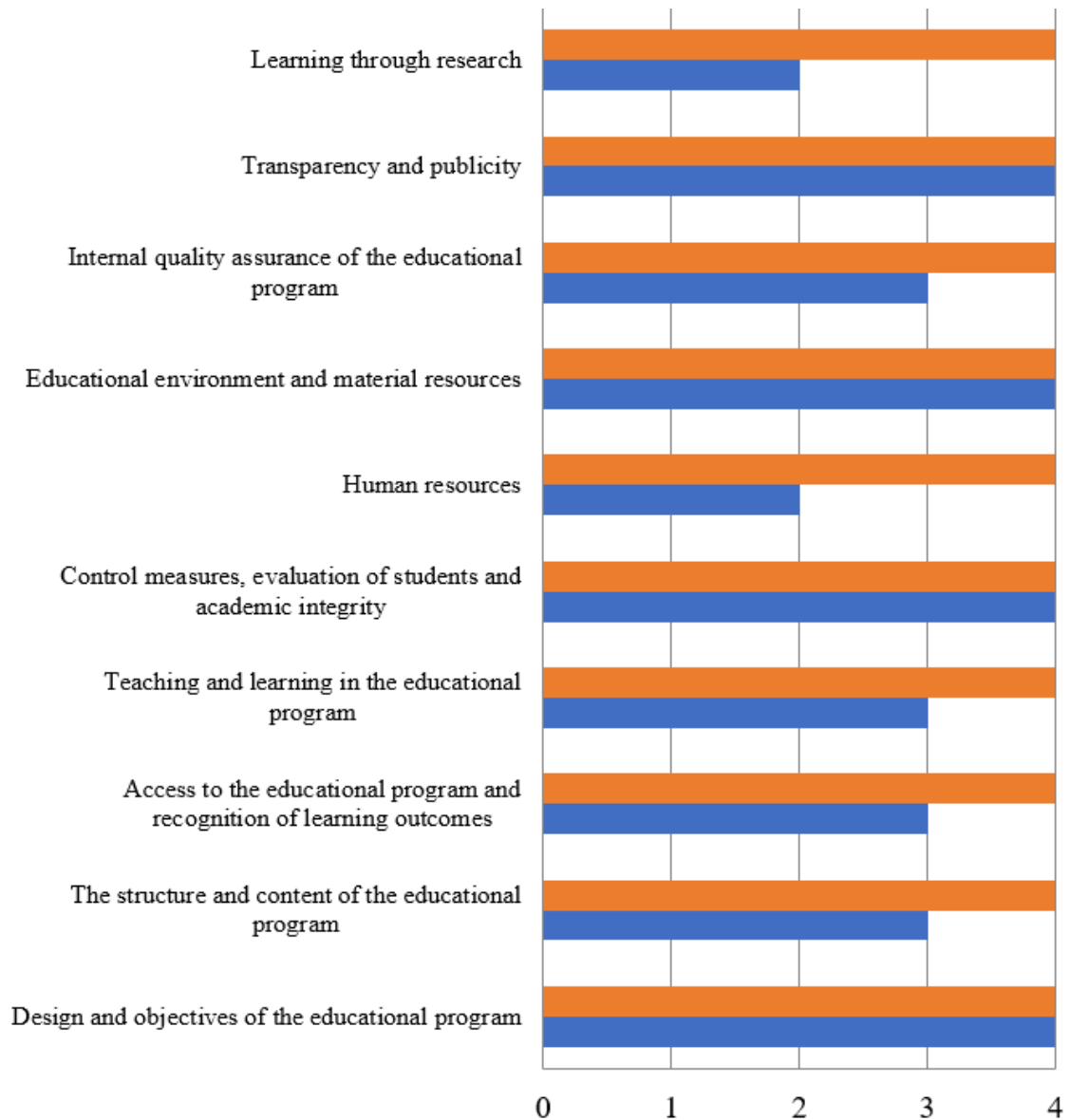
Figure 5: Description of the educational program and educational environment (comparative data of rating agencies, visualization, random data): 0 – the parameter is not applied; 1 – parameter mismatch; 2 – critical remarks that can be eliminated; 3 – compliance of the parameter; 4 – compliance of the innovative parameter.

2. During the creation of the first version of the algorithm for managing a certain indicator of the quality of education – based on the "gray" box model.
3. Searching for bugs – a "white" box model during trial and post-testing.

Testing the "quality of education" system can be demonstrated by the evolution of rating methods at the local (university), national and international levels [3, 5, 6]. Quality assessment by
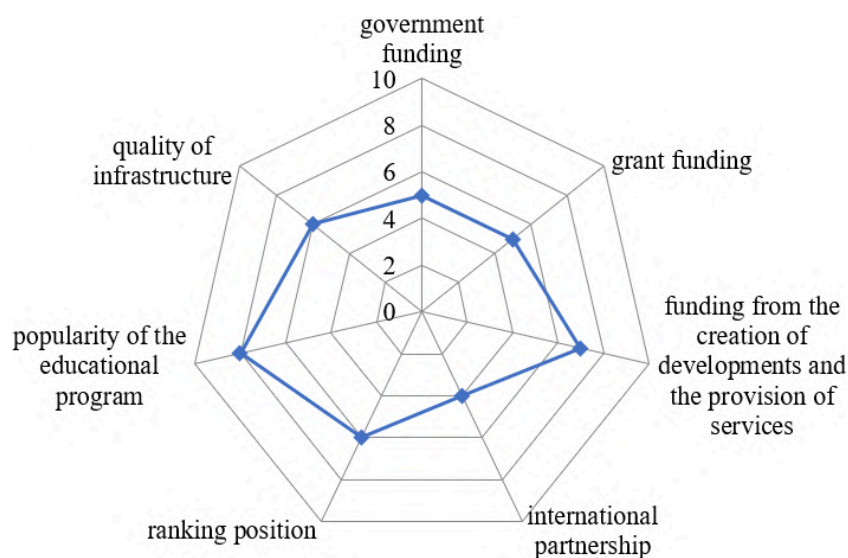
Figure 6: Assessment of the influence degree of the control parameter on the output parameter (visualization, random data).

rating parameters is a process that evaluates the contribution and "weight" of various indicators to the final success of the university. At the same time, the cyclicality of reviewing rating indicators and the degree of their influence depends on the response of external stakeholders and system bugs.

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