

# MEASURING THE EFFECTIVENESS OF THE IMPLEMENTATION OF INDIVIDUAL EDUCATIONAL TRAJECTORIES BY UNIVERSITY STUDENTS

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**Abstract.** Modern information and communication technologies allow to successfully use the methods of effectiveness measurement of various processes in particular in the field of education. From our perspective, success in the implementation of individual educational trajectories by university students requires the assessment model based on the use of modern information technology. In this article, we propose our own methodology for such measuring. It takes into account the entrant's competitive score and student's rating score. The user of the created system can choose the necessary information by criteria such as higher education degree, the form of study, department, and using the graph visualize the implementation of each student's educational trajectory. The presented methodology allows for evaluating objectively the quality of students' individual study plans and can be used in the development of universities rating and ranking criteria.

**Keywords:** individual educational trajectory, effectiveness measurement, information and communication technologies, university education, verification methods.

## Introduction

A substantial reorganization of university education is taking place in Ukraine at the present time. An example of this process is the establishment of the National Agency for Higher Education Quality Assurance in 2015. It is a permanent collegial body empowered to implement state policy in this area. Its powers include the following: development of the standards and criteria of higher education quality assurance, development of the procedure for accreditation of higher education institutions; analysis of the universities activities quality; conducting a licensing examination; preparation of an expert opinion on the possibility of issuing a license to carry out educational activities

in the field of higher education; formation of criteria for quality assessment of higher education institutions activities on which ratings of these institutions be compiled etc [1]. The 2019 Report of the National Agency for Higher Education Quality Assurance emphasized that the problem of quality of higher education in Ukraine remains extremely important not only for integration into the European educational space but also for the cultural and economic development of the nation [2]. In particular, it is important to create a unified methodology for measuring the effectiveness of the implementation of individual educational trajectories by university students. The Law of Ukraine “On Education” (2017) defines this concept as a personal way of realizing the personal potential of an education recipient. It is formed taking into account the abilities, interests, needs, motivation, capabilities and experience of an education recipient and it is based on the choice of the types, forms and pace of education, the subjects of educational activities and the educational programs, educational disciplines and their level of complexity, methods and means of trainings. Individual educational trajectory can be implemented through an individual curriculum plan [3]. We believe that modern information and communication technologies, combined with verification methods, allow creating a valid methodology for measuring the effectiveness of the implementation of individual educational trajectories by university students. The article analyzes these issues.

## 1 Related work

In recent years, the issue of the quality of higher education in Ukraine has been the subject of a number of papers, in particular in the OECD “Reviews of Integrity in Education: Ukraine 2017” [4] and “Review of the Education Sector” in Ukraine presented by the World Bank [5]. The publication of the Konrad Adenauer Foundation “Higher Education in Ukraine: Agenda for Reforms” [6], prepared by authors from universities and Ukrainian and German academic institutions with the participation of Educational Trends analytical agency analyzes major changes in the field of higher education in Ukraine. The authors paid special attention to the reforms related to the adoption of the Law of Ukraine “On Higher Education” (2014) in the new version. The beginning of implementation in our country of the requirements provided by “The Standards and guidelines for quality assurance in the European Higher Education Area” was acknowledged. It is emphasized that the creation of a modern system of higher education quality assurance is a commitment of Ukraine in accordance with The Ukraine–European Union Association Agreement. The aforementioned 2019 Report of the National Agency for Higher Education Quality Assurance highlights a number of problems in modern higher education in Ukraine. Firstly, the very concept of “quality of higher education” has become relative against the background of a diverse and fleeting market. Secondly, measuring this quality based on certain indicators is problematic and not perfect. Thirdly, the issue of developing objective criteria for rating and ranking of higher educational institutions remains debatable [2].

For example, at Lithuanian Sports University they decided to find criteria of education quality assessment with a help of questionnaire which was given to students. Such quality assurance criteria were investigated: 23 factors that could determine education quality; 33 statement about role of teaching staff and its influence; 35 methods

that could determine material quality on lectures; 14 methods with accessible learning resources for subjects.

In conclusion they found that contents of study, form of curriculum, teaching staff achievements, the level of funding as well as infrastructure, using IT systems and public information were the most important criterias in studying process [12].

Individual monitoring of German universities quality assessment presents individual achievements of each student separately as well as each teacher. Intra-university assessment of education quality includes such criterias as: separate assessment of each student or teacher achievements; teachers monitor the students achievements during the educational process by themselves; administrative assessment is done by the administration of university in the system direction and control [13].

Issued by the Norwegian Agency for Quality Assurance in Education criteria for analysis of quality assurance systems shall involve the entire establishment and shall apply to the square measures of activity that are associated with quality of studies and also the total learning surroundings for all course provisions that the establishment is accountable, each internal and external. In evaluating the standard assurance system, stress is placed on the subsequent aspects of the system.

Active participation by students in work on quality and also the concentrate on the overall learning environment. An annual report on work on quality to the board of the establishment, giving a coherent overall assessment of quality of studies at the establishment and an summary after all plans and measures for work on quality [14].

How the college rankings were calculated in USA.

These square measure the factors and weights utilized in the U.S. News Best schools rankings.

They approach outcomes (35%) from angles of graduation and retention (22%), graduation rate performance (8%) and social quality (5%).

Graduation rate performance: they compared every college's actual six-year graduation rate with what we tend to foretold for its fall 2012 coming into category. the anticipated rates were sculptural from admissions information, proportion of undergraduates awarded Pell Grants, faculty money resources, proportion of federal help recipients World Health Organization square measure 1st generation, and National Universities' maths and science, or STEM, orientations.

Social mobility: Measures however well colleges graduated students World Health Organization received federal Pell Grants (those generally coming back from households whose family incomes square measure but \$50,000 annually, although most Pell Grant cash goes to students with a complete family financial gain below \$20,000).

They conjointly aforementioned however the graduation and retention rate benchmark ranking was calculated. it's all over again computed from a school's total score in these 2 ranking indicators: average six-year graduation rate and average freshman retention rate [15].

Faculty Resources (20%)

Research shows the bigger access students ought to quality instructors, the a lot of engaged they'll be in school and therefore the a lot of they'll learn and sure graduate. U.S. News uses 5 factors from the 2018-2019 year to assess a school's commitment to instruction: category size, college regular payment, college with the very best degree in their fields, student-faculty magnitude relation and proportion of school World Health Organization square measure full time.

#### Expert Opinion (20%)

Academic name matters as a result of it factors things that can't simply be captured elsewhere. as an example, an establishment well-known for having innovative approaches to teaching could perform particularly well on this indicator, whereas a college troubled to stay its certification can probably perform poorly.

#### Financial Resources (10%)

Generous per-student defrayment indicates that a university offers a large style of programs and services. U.S. News measures money resources by victimization the typical defrayment per student on instruction, research, student services and connected academic expenditures within the 2017 and 2018 business enterprise years. defrayment on sports, dorms and hospitals doesn't count.

#### Student Excellence (10%)

A school's educational atmosphere is influenced by the property of its admissions. Simply put, students World Health Organization achieved sturdy grades and take a look at scores throughout high school have the very best likelihood of succeeding at difficult college-level coursework; sanctioning instructors to style categories that have nice rigor.

#### Alumni Giving (5%)

This is the typical share of living alumni with bachelor's degrees World Health Organization gave to their faculty throughout 2016-2017 and 2017-2018. Giving measures student satisfaction and post-graduate engagement.

## 2 The System description

The purpose of the development of our methodology is measuring the effectiveness of the implementation of individual educational trajectories by university students using modern information and communication technologies. The starting point of measurement is the indicators with which the applicants are enrolled in a higher education institution [7]. Further, rating scores for the appointment of academic scholarships for students of Kherson State University were taken into account [8]. This information is generally summarized and presented in Table 1:

**Table 1.** Indicators of measuring the effectiveness of the implementation of individual educational trajectories by university students

<b>Categories of persons / selection criteria</b>	<b>Applicants for Bachelor's Degree</b>	<b>Applicants for Master's Degree</b>	<b>Higher Education Recipient</b>	<b>Alumni</b>
Enrollment based on interview results	+	-	-	-
Competitive (rating) score*	+	+	+	-

\*The rating score for the award of academic scholarships to students at KSU is equated with the competitive score by application for the Bachelor's and Master's degrees.

An explanation of some used criteria and concepts in accordance with the "Rules for Entrance to Kherson State University in 2020" [8] is given in Table 2:

**Table 2.** An explanation of used criteria and concepts

Components of measurement	Contents of the component
Interview	Is the form of the entrance test that involves assessing the preparedness and motivation of the applicant. Based on its results, a protocol decision is made regarding providing an applicant with a recommendation for admission.
Competitive score	Is a comprehensive assessment of the applicant's achievements. The calculation based on the results of entrance tests and other indicators up to 0,001 in accordance with the Entrance Terms and Conditions.
Competitive score for enrollment to the first year for gaining Bachelor's Degree (Master's Degree in the field of medicine) based on the complete general secondary education	<p>Competitive score (CS) = <math>C1*S1 + C2*S2 + C3*S3 + K4*A + C5*OU</math>, where C1, C2, C3, C4, C5 are integral weighting coefficients. Their sum for each competition proposal must be equal to 1;</p> <p>S1, S2 - External independent testing (EIT) scores or entrance exams scores of the first and second subjects;</p> <p>S3 - External independent testing (EIT) scores or entrance exams scores of the third subjects and creative competition;</p> <p>A - the average grade of the document on the complete secondary education;</p> <p>OU - a score for the successful completion of the KSU preparatory courses of the specialty, which is given special support.</p> <p>Finally, the competitive score is multiplied by the product of the following factors: AC, IC, RC, PC.</p> <p>The maximum competitive score may not exceed the figures 200.</p>
Competitive score for entrance to Master's degree based on the obtained higher education degree (educational and qualification level).	<p>a) for entrance for the Master's degree in specialty in specialty 081 "Law", in other specialties (except the specialties of branches of knowledge 01 "Education / Pedagogy", specialties 025 "Musical art") according to the formula: Competitive score (CS) = <math>P1 + P2 + P3</math>, where the components take into account the specifics of certain specialties;</p> <p>b) in other cases, the competitive score is calculated as the sum of the entrance</p>

	exam scores and the average score of the supplement to the document on preliminary education, taking into account the right to the primary enrollment (by multiplying the competition score by 1.05) to higher medical and pedagogical institutions.
Rating score	<p>Determines a person's place in the ranking for an academic scholarship.</p> <p>Consists of average success score and additional scores.</p> <p>The average success score of student's academic achievements according to the results of semester control is determined on a 100 point scale of assessment. It is 95% of the rating score. Additional scores are 5% (4.75 scores). They are calculated according to the following indicators:</p> <ul style="list-style-type: none"> <li>a) achievements in scientific, scientific and technical activities (2.5% additional scores, maximum - 2,375 scores);</li> <li>b) active participation in international programs, projects, seminars, forums, competitions (1% additional scores, maximum - 0.95 scores);</li> <li>c) active participation in public life (1.5% additional scores, maximum - 1,425 scores).</li> </ul> <p>It follows that the maximum student rating score - 104.75 scores (100 scores is the maximum success score + 4.75 is the maximum number of additional scores).</p>

So, we get the initial information from website Vstup.Info. With the help of the parser developed by us, we collect entrants' competitive scores. If a person is enrolled in university, we enter his name and score in the database.

At the same time, we turn the competitive score on a 200-point scale into a 100-point scale in advance. The results of the session a Dean's Office submits in xml file format. The administrator of this platform downloads student success data. According to the results of the semester exams, it is the main information for assessing and rating a student.

As can be seen from the Table 2, the rating score includes the average study score and other scores, including scores for the participation in scientific activities. As the student participates in the scientific activity of the department and faculty, the participation in conferences, publication of articles and abstracts are taken into account. In the articles [9-11], the architecture of the system for scientific activity results evaluating of academic

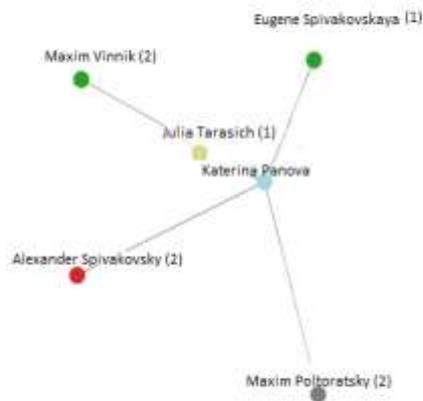
staff and students based on the following scientometric systems and databases Scopus, WOS, Google Scholar is described.

After passing the exams, the rating examiner checks whether the student has a publications. This can be done through the KSU Publication service. The list of articles written by student K. Panova is given in Table 3.

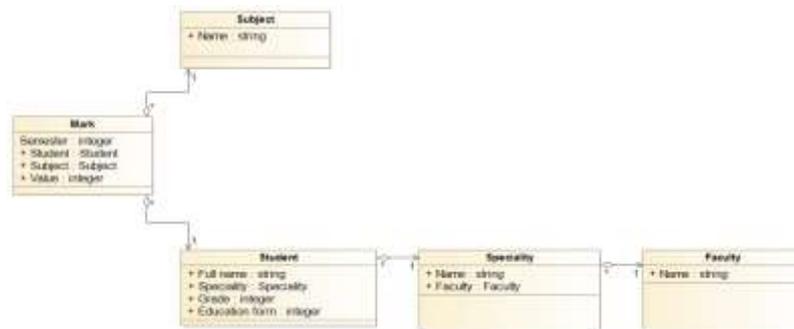
**Table 3.** List of articles written by student K. Panova

Title of the article	Scopus	Google Scholar	Web of science	Semantic Scholar
Development of rating systems for scientometric indices of universities	+	+	-	+
Information system of scientific activity indicators of scientific organizations: Development status and prospects	+	+	-	+

This system displays a graph indicating the connections between the authors.



**Fig. 1.** Connections between co-authors of student K. Panova  
The model of data representation in the rating system is presented in Figure 2:



**Fig. 2.** Model of data representation in the rating system

1. Assessment is the entity, will include such entities as the subject and the student.
2. Student is the entity, will be used as the external key in the entity Assessment.
3. The subject is the entity will be used as the external key in the entity Assessment.
4. Specialty is the entity, will be used as the external key of the Student entity and contains the Faculty entity.
5. Faculty is the entity, will be used as the external key of the Specialty entity. For now, we will analyze the data of only one faculty. In the future, we assume the possibility of the developing of data on several other faculties.

The "administrator" of the system can take such actions:

- Add (delete) the following entities:
  - student,
  - discipline,
  - specialty,
  - rating,
  - faculty.
- Filter by:
  - form of study,
  - higher education degree,
  - specialty.
- Search by:
  - name,
  - specialty,
  - discipline,
  - rating.

It is possible to visualize these requirements with the help of use-case diagrams (Figure 3).

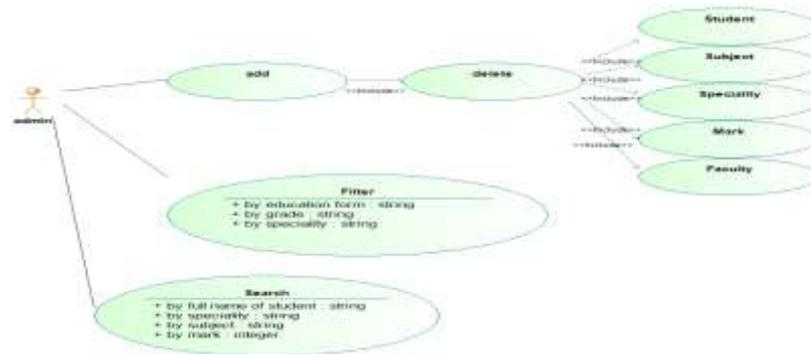


Fig. 3. System Administrator actions

Based on the previous actions we obtain the result presented in Figure 4:

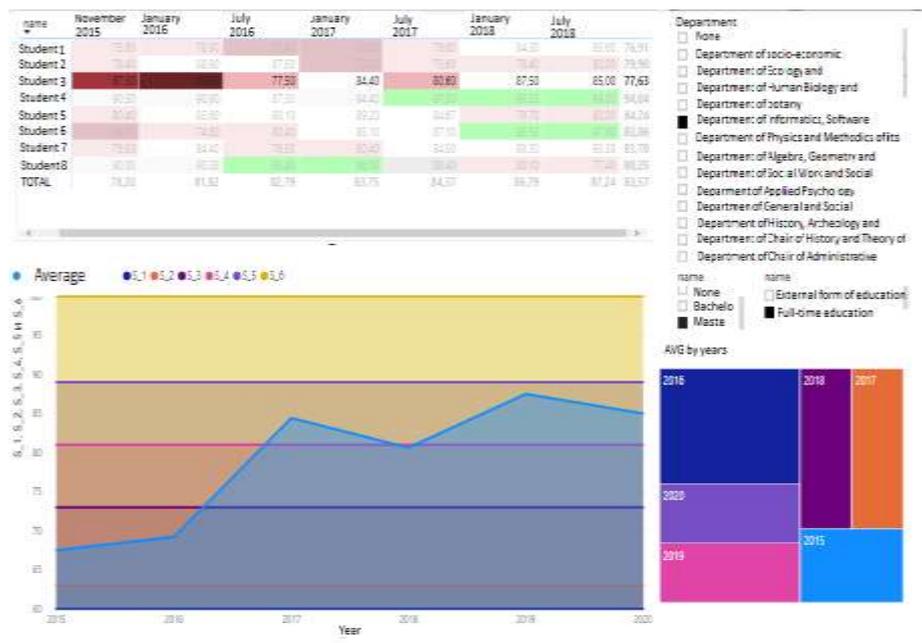


Fig. 4. The basic software of the created system

As can be seen from Figure 5, the system user is able to select the required information by degree, form of study, department, as well as visualize the implementation of the educational trajectory of each student using a graph. Figure 6 shows how filters can determine when a bachelor's student completed the educational trajectory most effectively and vice versa.

name	September 2015	January 2016	July 2016	January 2017	July 2018	January 2019	July 2019	TOTAL
Student 1	90,50	90,90	87,50	94,40	97,50	98,50	99,00	94,04
Student 2	90,00	90,38	95,45	96,00	88,40	80,10	77,40	88,25
Student 3	80,40	85,60	90,10	89,20	84,67	79,70	80,00	84,24
Student 4	66,70	74,60	80,40	85,10	87,10	95,50	97,60	83,86
Student 5	76,50	84,40	76,50	80,40	84,50	90,30	93,30	83,70
Student 6	78,40	88,90	87,50	76,30	75,60	78,40	80,00	79,90
Student 7	87,30	87,30	77,50	84,40	80,60	87,50	85,00	77,63
Student 8	75,60	78,90	87,40	70,00	76,60	84,30	85,60	76,91
TOTAL	78,20	81,82	82,79	83,75	84,37	86,79	87,24	83,57

Fig. 5. Visualization of the implementation of educational trajectories by students

Below is a visualization of the implementation of educational trajectories by Master's Degree students (Figure 6):

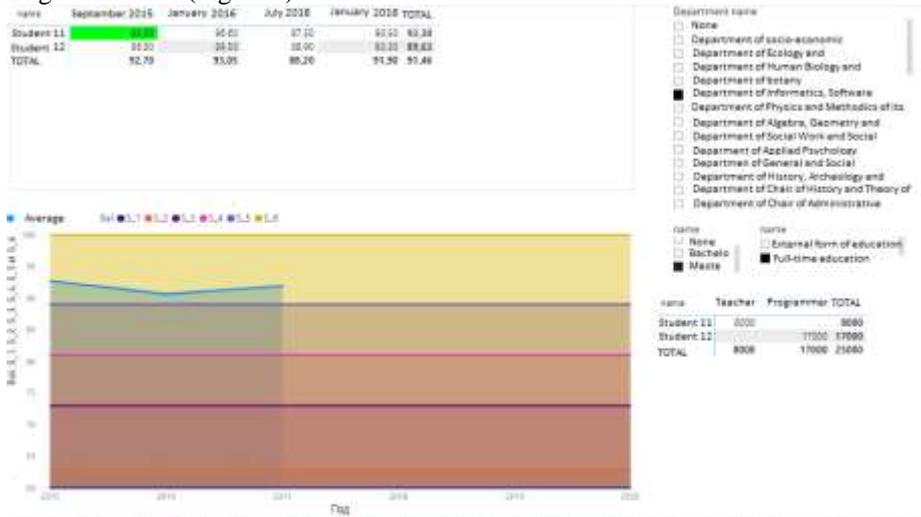


Fig. 6. Visualization of the implementation of educational trajectories by Master's degree students

## Conclusions

It was concluded that the proposed model allows measuring the efficiency of the implementation of individual educational trajectories by university students based on higher education degree, a form of study and the department. The presented method also allows objective evaluating the quality of individual curricula plan of students and can be used in developing criteria for ranking and rating of universities.

It is suggested that based on the trajectories of student success, using the methods and tools of machine learning (ML), the demonstration of malicious behavior of participants in the educational process can be tracked.

By malicious behavior we mean illegal behavior of a student and / or scientific and pedagogical staff, which is manifested in the following violations of academic integrity as defined by Article 42 of the Law of Ukraine "On Education":

- corrupt practices is the provision (reception) by a participant of the educational process or a proposal to provide (receive) funds, property, services, benefits or any other benefits of a material or intangible nature in order to obtain an undue advantage in the educational process;
- biased assessment - deliberate overestimation or underestimation of the assessment of learning outcomes of students;
- providing assistance to students during their assessment of learning outcomes or creating obstacles that are not provided by the conditions and / or procedures for such assessment.

The following trajectories can be considered as patterns of criminal behavior that are indicators:

1. The student(s) has a volatile curve, the average score constantly fluctuates from low to high and from high to low.
2. The student(s) throughout the period of study has / have a low average score, and at the certification receive a high.

These patterns may indicate bribery, biased assessment, and the provision of learning outcomes to learners during their assessment that are not covered by the conditions and / or procedures for such assessment.

These patterns may indicate corrupt practices, biased assessment, and the provision of learning outcomes to learners during their assessment that are not covered by the conditions and / or procedures for such assessment.

3. The student has a high average score throughout the study and at the certification receives a low score.

This result may indicate a violation of the student's right to a fair and objective assessment of learning outcomes due to the biased attitude of the researcher to the student.

Using the proposed approach, the algorithm can be trained in the first three cases and trace other malicious behavior, which is a combination of the three options described above. We also emphasize that the grounds for raising the issue of establishing the facts of academic dishonesty of participants in the educational process, in our opinion, can only be systemic cases, individual ones should be considered as an error.

Prospects for further research are to develop a model for measuring the effectiveness of the implementation of individual educational trajectories by university students which will include success indicators of graduate student, such as employment, salary etc.

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