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MATHEMATICAL MODEL FOR DETERMINATION OF FORMATION PROFESSIONAL COMPETENCE LEVEL OF BACHELORS IN THE FIELD OF A CONSTRUCTION

Abstract. In the article competences of bachelors and areas of the Construction regulated Federal State educational standards of the higher education (FSES HE) are considered. Level approach for assessment of their formation is offered (low, medium, basic, high). The substantial essence of each of levels is provided. According to the educational standard professional competences are considered in the following areas: prospecting and design activities (P&DA); production and technological and production management activity (PT&PMA); experimental and research activities (ERA); assembly and adjustment and service and operational activities (AA&SOA); business activity (BA). The mathematical model based on a method of standardization of ranks which allows to receive numerical intervals for assessment of level of formation of competence of this or that area is developed for each type of professional activity.

The algorithm of a mathematical model creation is considered. The procedure of reduction of rank estimates to a comparable form is called standardization of ranks and, in our case, will consist in the procedure of simple uniform stretching of shorter scales to the required length. For each attribute the current standardized rank is equal to a difference between the maximum and minimum appointed ranks of attribute, divided into quantity of empty cages. After holding a procedure of standardization of ranks function which behavior allows to define 4 numerical intervals which can be used for determination of level of formation of professional competences of bachelors of this or that field of construction is based.

Practical application of the developed mathematical model assumes automation of process of an assessment of level of formation of professional competence of this or that sphere of activity by means of realization in the form of the interactive program module and development of the special educational and methodical materials allowing to show to future bachelor-builder existence of practical experience in the studied spheres of activity.

Keywords. Mathematical model, method of standardization of ranks, levels of formation of professional competence, estimative intervals.

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МАТЕМАТИЧЕСКАЯ МОДЕЛЬ ДЛЯ ОПРЕДЕЛЕНИЯ УРОВНЯ СФОРМИРОВАННОСТИ ПРОФЕССИОНАЛЬНОЙ КОМПЕТЕНТНОСТИ БАКАЛАВРОВ В ОБЛАСТИ СТРОИТЕЛЬСТВА

Аннотация. В статье рассмотрены компетенции бакалавров а области Строительства, регламентированные Федеральным образовательным стандартов высшего образования. Предложен уровневый подход для оценки их сформированности (низкий, средний, базовый, высокий). Представлена содержательная сущность каждого из уровней. Согласно образовательного стандарта профессиональные компетенции рассмотрены в следующих областях: изыскательской и проектно-конструкторской деятельности (И и ПКД); производственно-технологической и производственно-управленческой деятельности (ПТ и ПУД); экспериментально-исследовательской деятельности (ЭИД); монтажно-наладочной и сервисно-эксплуатационной деятельности (МН и СЭД); предпринимательской деятельности (ПД). Для каждого вида профессиональной деятельности разработана математическая модель, основанная на методе стандартизации рангов, которая позволяет получить числовые интервалы для оценки уровня сформированности компетентности в той или иной области. Рассмотрен алгоритм построения математической модели.

Процедура приведения ранговых оценок к сопоставимому виду называется стандартизацией рангов и, в нашем случае, будет состоять в процедуре простого равномерного растяжения более коротких шкал до требуемой длины. Для каждого атрибута текущий стандартизованный ранг равен разности между максимальным и минимальным назначенными рангами атрибута, деленной на количество пустых клеток. После проведения процедуры стандартизации рангов строится функция, поведение которой позволяет определить 4 числовых интервала, которые могут быть использованы для определения уровня сформированности профессиональных компетенций бакалавров в той или иной области строительства.

Практическое применение разработанной математической модели предполагает автоматизацию процесса оценки уровня сформированности профессиональной компетентности в той или иной области деятельности посредством реализации в виде интерактивного программного модуля и разработку специальных учебно-методических материалов, позволяющих продемонстрировать будущему бакалавру-строителю наличие практического опыта в исследуемых областях деятельности.

Ключевые слова. Математическая модель, метод стандартизации рангов, уровни сформированности профессиональной компетентности, оценочные интервалы.

The competency structure of the bachelor studying in the direction 08.03.01 the Construction according to Federal state educational standard of the higher education FSES HE [13], includes competences of three types: common cultural, all-professional and professional. The greatest interest in the conditions of the market relations and the increased requirements of employers to level of training of university graduates is represented by professional competences.

Professional competences according to FSES HE in the direction of Construction are considered in areas [13]:

- prospecting and design activities (P&DA);
- production and technological and production management activity (PT& PMA);
- experimental and research activities (E&RA);
- assembly and adjustment and service and operational activities (AA&SOA);
- business activity (BA).

Creation of mathematical model for determination of level of formation of professional competence of this or that subject domain is based on the theoretical provisions published in work [5,6,7].

According to the competence-based approach in education [3,11] assuming identification of theoretical and practical aspects of educational process on the basis of formation of set of knowledge, abilities and experience of different types of activity, the student has to be able to show the abilities in practice.

Level approach to an assessment of assimilation of a training material is based on B. Blum [2] taxonomy offered in 1956 and assuming presence of 6 levels of cogitative abilities of the student: knowledge, understanding, application, analysis, synthesis, assessment. B. Blum's ideas have gained development in pedagogical researches of Lebedev O. E., Maximova V. N., Simonov V. P., Skatkin M. N., Teslenko V. I., etc. The greatest distribution in domestic pedagogical science was gained by Bespalko's approach Accusative [1] which has offered 4 levels of assimilation of a training material: low - student's (recognition), medium - algorithmic (the solution of standard tasks), basic - heuristic (the action choice), high - creative (action search).

Extrapolating level approach to formation the professional competences according to Bespalko V. P. [1] we will consider low, medium, basic and high the level of their formation.

The low level of formation of professional competences at the bachelor is characterized by experience on distinction, recognition of professional objects, concepts, terms at repeated perception of earlier studied material, on performance of actions with them, but "with the hint", retelling and copying of educational information.

The medium level of formation of professional competences at the bachelor is characterized by experience on independent reproduction and application of professional information in the standard situations considered earlier in training activity.

The basic level of formation of professional competences at the bachelor is characterized by experience on use of the acquired professional knowledge and abilities in atypical situations, to obtaining new knowledge by action of a sample.

The high level of formation of professional competences at the bachelor is characterized by experience of action in unforeseen situations and creation of new algorithms, rules, actions, that is subjectively new information.

In the course of examination of level of formation of professional competences of bachelors of construction area, according to Novikova T. G. researches [8], we will construct mathematical model for definition of numerical intervals for their assessment. Object of examination – process of formation of professional competences of bachelors of construction area, means of examination – mathematical model, the procedure of examination — joint activity of skilled experts (experts), an examination product — the expert opinion, after coordination by the criteria offered for examination.

As attributes of process [4,9,12] of formation of professional competences (PC) we will consider the regulated FSES HE competence in construction, and as signs of these attributes we will consider extents of manifestation of these competences at the bachelor.

Determination of level of formation of professional competences of the bachelor in prospecting and design activity

Let's consider area of prospecting and design activity (P&DA) bachelors. Requirements of FSES HE and their detailed specification are submitted in the left extreme column of table 1.

Table 1

The regulated FSES HE the list of professional competences of the bachelor in the Construction direction in the field of prospecting and design activity

The list of the competences regulated by FSES HE in the field of P&DA	The graduate shows:	Appointed ranks
PC-1: knows the regulatory base in the field of engineering researches, the principles of design of buildings, constructions, engineering systems and the equipment, planning and building of the inhabited places	Knowledge of the regulatory base in the field of engineering researches at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	Knowledge of the principles of design of buildings, constructions, engineering systems and the equipment, planning and building of the inhabited places at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-1: owns methods of carrying out engineering researches, technology of design of details and designs according to S	ability to own methods of carrying out engineering researches at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4

The list of the competences regulated by FSES HE in the field of P&DA	The graduate shows:	Appointed ranks
with use universal and specialized by PCS and SAD	ability to own technology of design of details and designs according to the specification (S)	5
	At the medium level	6
	At the basic level	7
	At the high level	8
	skills of use of the universal and specialized program computer systems (PCS) and systems of automation of design (SAD) at a low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12
PC-2: it is capable to carry out the preliminary feasibility study on design decisions	Ability to carry out the preliminary feasibility study on design decisions at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-2: it is capable to develop project and working documentation	Ability to develop the project documentation at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	ability to develop working documentation at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-3: it is capable to make out the finished construction work	Ability to make out the finished construction work at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-3: it is capable to control compliance of the developed projects and technical documentation of standards, specifications and other normative documents	Ability to control compliance of the developed projects and technical documentation to the specification (S) at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	Ability to control compliance of the developed projects and technical documentation to standards, specifications and other normative documents at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8

STEP 1. Let's describe pedagogical process of formation of competences of bachelors of area in the area P&DA by means of attributes and signs

corresponding to them. Results of this step are presented on medium a column of tab. 1.

STEP 2. Let's appoint to signs of attributes of the studied process ranks. Results of this step are presented in the right extreme column in tab. 1. Let's write out values of the appointed ranks in table 2.

Table 2

Value of the appointed ranks to attributes process of formation of competences of the bachelor of area P&DA

No. attribute P&DA	Appointed ranks											
1(PC-1)	1	2	3	4	5	6	7	8				
2 (PC-1)	1	2	3	4	5	6	7	8	9	10	11	12
3(PC-2)	1	2	3	4								
4(PC-2)	1	2	3	4	5	6	7	8				
5(PC-3)	1	2	3	4								
6(PC-3)	1	2	3	4	5	6	7	8				

In order that it was possible to compare signs of attributes among themselves, it is necessary to carry out the procedure of standardization of ranks which consists in stretching of shorter attributes to the longest [5,10].

STEP 3. Let's make the procedure of standardization of ranks which results are presented in tab. 3.

Table 3

Values of the standardized ranks on signs of attributes of process of formation of competences of the bachelor of BI of area P&DA

No. attribute P&DA	Standardized ranks											
1	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
2	1	2	3	4	5	6	7	8	9	10	11	12
3	1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	4
4	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
5	1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	4
6	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
Av.val.	1	0,78	0,95	1,12	1,28	1,45	1,62	1,78	1,95	2,12	2,28	7,33

As a result of carrying out standardization of ranks we have received the table valued function and presented in tab. 4.

Table 4

Table valued function for determining level of formation of professional competences of bachelors of BI in the area P&DA

X	1	2	3	4	5	6	7	8	9	10	11	12
У	1	0,78	0,95	1,12	1,28	1,45	1,62	1,78	1,95	2,12	2,28	7,33

STEP 4. Let's construct the schedule of this function on a piece [1,12] (fig. 1).

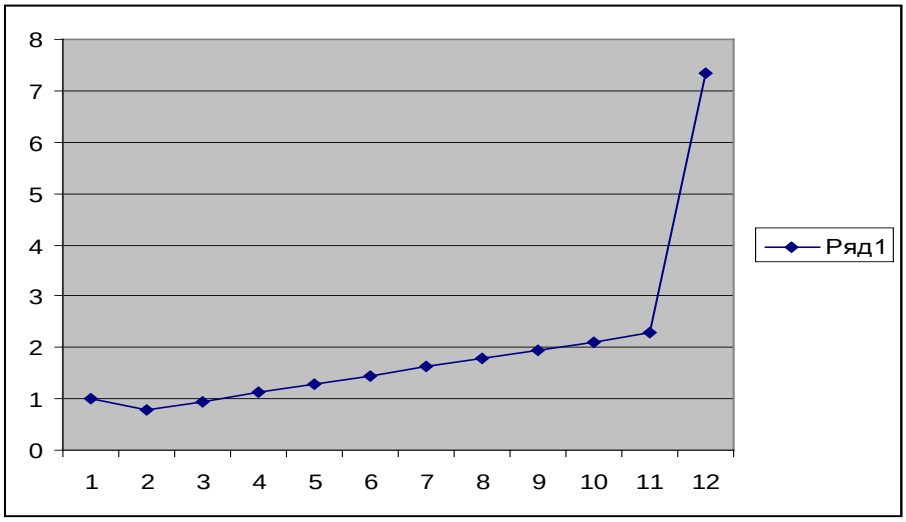

Fig.1. The schedule of change of medium values of ranks when determining level of formation of professional competences of bachelors in the area P&DA at bachelors of BI

In fig. 1 follows from the schedule that the interval [1,12] breaks border points 2, 3 and 11 into 4 areas. The result of recalculation of border points for definition of estimated intervals is presented in tab. 5.

Table 5

Results of recalculation values of border points in estimated intervals when determining level of formation of competences of bachelors of BI in the area P&DA

Values boundary ranks	% of values boundary ranks from the maximum quantity of ranks (12)	Sum of ranks, corresponding to border points (from the sum of the maximum ranks (44)	Estimated Interval
2	17	7	$\sum \leq 7$
3	25	11	$8 \leq \sum \leq 11$
11	92	40	$12 \leq \sum \leq 40$

Now it is possible to formulate final estimated intervals for determination of level of formation of competences of bachelors of BI in prospecting and design activity which are presented in tab. 6.

Table 6

Estimated intervals for determination of level formation of professional competences of bachelors of BI in the area P&DA

No.	Sum of ranks	Recommendations of the expert
1	The sum of ranks is less than 7 points	In the area P&DA professional competences are created at a low level
2	The sum of ranks is from 8 to 11 points	In the area P&DA professional competences are created at the medium level
3	The sum of ranks is from 12 to 40 points	In the area P&DA professional competences are created at the basic level
4	The sum of ranks is more 40 points	In the area P&DA professional competences are created At the high level

The definition of the competence level of bachelor of BI in the field of production technology and production management activity (PT& PMA)

FSES HE requirements and detailed specification of competences of bachelors of BI in the field of PT&PM are presented in table.7.

Table 7

Regulated list of competences of the bachelor of BI in the field of production technology and production management activity

The list of the competences regulated by FSES HE in the field of PT&PM	The graduate shows:	Appointed Ranks
PC-4: ability to participate in the design and finding of objects of professional activity	The ability to participate in the design and finding of objects of professional activity at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-5: knows the requirements of the occupational health, safety and environmental protection when performing construction, repairs and reconstruction of construction objects	Knowledge of health and safety requirements at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	Knowledge of the requirements of health and safety at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
	Knowledge of the requirements of environmental protection at the low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12
PC-6: ability implement and organize technical operation of buildings and constructions of objects of housing and communal services (HCS)	The ability to implement and organize the technical maintenance of the buildings and facilities of HCS at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-6: ability to ensure the reliability, safety and efficiency of the buildings and facilities of HCS	The ability to provide reliability, safety and efficiency of buildings and construction of housing facilities at the low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-7: ability to analyse technical efficiency of production units and to develop measures for its improvement	The ability to analyze the technical efficiency of production units and to develop measures for its improvement at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4

The list of the competences regulated by FSES HE in the field of PT&PM	The graduate shows:	Appointed Ranks
PC-7: ability to analyse and economic efficiency of a production unit and to develop measures for its improvement	The ability to analyze and efficiency of a production unit and to develop measures for its improvement at the low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-8: owns the technology, methods, debugging and development of technological processes of construction, operation, maintenance of buildings, engineering systems	The technology skills, methods, debugging and development of technological processes of building production at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	The technology skills, methods, debugging and development of technological processes of operation, maintenance of buildings, engineering systems at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-8: Owns the technology, methods, debugging and development of technological processes of production of building materials, products and structures, machinery and equipment	The technology skills, methods, debugging and development of technological processes of production of building materials at a low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12
	The technology skills, methods, debugging and development of technological processes of manufacture of building products and structures at a low level	13
	At the medium level	14
	At the basic level	15
	At the high level	16
	The technology skills, methods, debugging and development of technological processes of production of building machinery and equipment at the low level	17
	At the medium level	18
	At the basic level	19
	At the high level	20
PC-9: ability to prepare documentation for quality management and standard methods of quality control of technological processes at production sites	The ability to prepare documentation for quality management and standard methods of quality control of technological processes at production sites at the low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-9: ability	The ability to organize jobs, provide technical	5

The list of the competences regulated by FSES HE in the field of PT&PM	The graduate shows:	Appointed Ranks
to organize jobs, provide technical equipment, accommodation and maintenance of technological equipment	equipment, accommodation and maintenance of technological equipment at a low level	
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-9: ability to exercise control of observance of technological discipline, labor protection and environmental safety	The ability to exercise control of observance of technological discipline, labor protection and environmental safety at a low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12
PC-10: knows the organizational-legal foundations of business and management in the sphere of construction and housing	Knowledge of the organizational-legal foundations of business and management in the sphere of construction and housing at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-10: Knows the basics of work planning personnel and payroll	Knowledge of the principles of planning personnel and payroll at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-11: a mastery of methods of implementation of innovative ideas, the organization of production and effective management of people	Possession of methods of implementation of innovative ideas, the organization of production and effective management of people at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-11: a mastery of methods of preparation of documentation for creation of system of quality management of the production unit	Possession of methods of preparation of documentation for creation of system of quality management of the production unit at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-12: ability to develop operational work plans of primary production units	The ability to develop operational work plans of primary production units at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-12: ability to conduct analysis of the costs and results of production activities	The ability to conduct cost analysis and manufacturing activities at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-12: ability to prepare technical documentation	Ability to prepare technical documentation and the established reporting on approved forms at a low	9

The list of the competences regulated by FSES HE in the field of PT&PM	The graduate shows:	Appointed Ranks
and the established reporting on approved forms	level	
	At the medium level	10
	At the basic level	11
	At the high level	12

STEP 1. We describe the pedagogical process of formation of competences of bachelors of BI in the field of production technology and production management activity by attributes and their corresponding characteristics. The results of this step are presented in the left and middle columns of the table. 7.

STEP 2. Assign the signs of the attributes of the process under study the ranks. The results of this step are presented in the rightmost column in table. 7. Write down the values assigned to the grades in table.8.

Table 8

Values assigned grade attributes process of formation of professional competence of bachelors of BI in the field of production technology and production management activity

No. attribute PT&PM	Appointed ranks																			
1 (PC-4)	1	2	3	4																
2 (PC-5)	1	2	3	4	5	6	7	8	9	10	11	12								
3 (PC-6)	1	2	3	4	5	6	7	8												
4 (PC-7)	1	2	3	4	5	6	7	8												
5 (PC-8)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6 (PC-9)	1	2	3	4	5	6	7	8	9	10	11	12								
7 (PC-10)	1	2	3	4	5	6	7	8												
8 (PC-11)	1	2	3	4	5	6	7	8												
9 (PC-12)	1	2	3	4	5	6	7	8	9	10	11	12								

STEP 3. Will produce the procedure of standardization of ranks, the results of which are presented in table. 9.

Table 9

Values of the standardized ranks on the grounds of attributes of the process of formation of competences of bachelors of BI PT&PMA

No. attribute PT&PM	Min	Standardized ranks																		Max
1	1	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	0,2	4
2	1	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	12
3	1	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	8
4	1	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	8
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	1	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	12
7	1	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	8
8	1	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	0,4	8
9	1	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	0,6	12
Av.val.	1	0,62	0,73	0,84	0,95	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,2	2,3	2,4	2,5	10,2

As a result of the standardization of ranks we now have a function that given table, and are presented in table. 10.

Table 10

Table valued function for determining level of formation of professional competences of bachelors of BI in the area PT&PMA

X	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
У	1	0,62	0,73	0,84	0,95	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,2	2,3	2,4	2,5	10,2

STEP 4. Let's plot this function on the interval [1,20] (Fig.2).

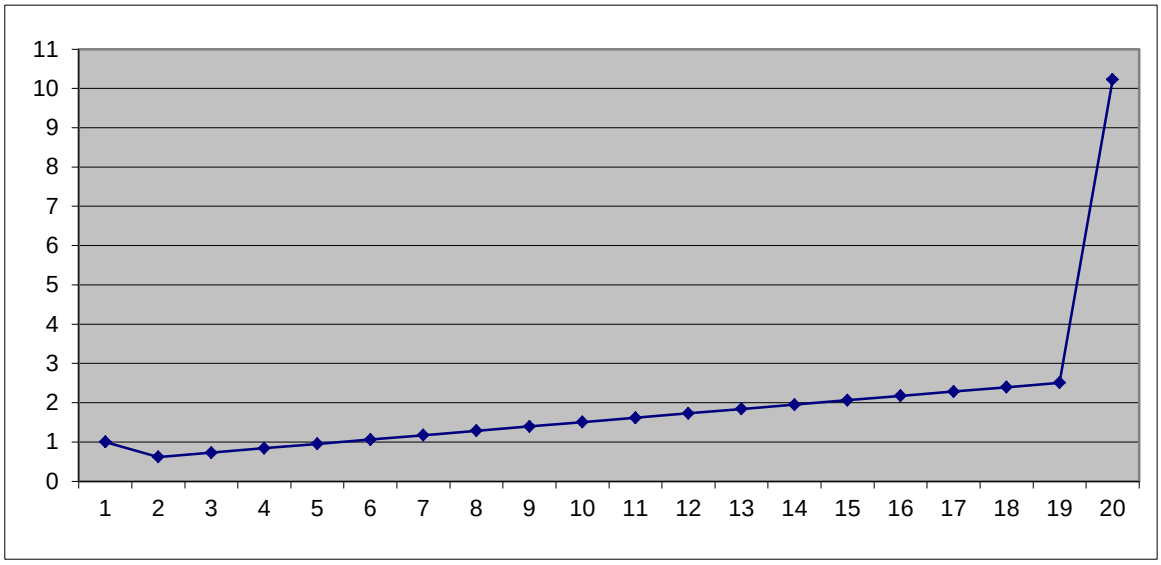

Figure 2. The schedule of change of medium values of ranks when determining level of formation of competences of bachelors of BI in in the field PT&PMA

In fig. 2 follows from the schedule that the interval [1,20] breaks border points 2, 5 and 19 into 4 areas. The result of recalculation of border points for definition of estimated intervals is presented in tab. 11.

Table 11

Results of recalculation values of border points in estimated intervals when determining level of formation of competences of bachelors of BI in the field of PT&PMA

Values boundary ranks	% of values boundary ranks from the maximum quantity of ranks (20)	Sum of ranks, corresponding to border points (from the sum of the maximum ranks (92)	Estimated Interval
2	10	9	$1 \le \sum \le 9$
5	25	23	$10 \le \sum \le 23$
19	95	81	$24 \le \sum \le 81$

Now it is possible to formulate final estimated intervals for determination of level of formation of competences of bachelors of BI in production and technological and production management activity which are presented in table 12.

Table 12

Estimated intervals for determination of level formation of professional competences of bachelors of BI in the field of PT&PMA

No.	Sum of ranks	Recommendations of the expert
1	The sum of ranks is less than 9 points	In the area PT&DPM professional competences are created at a low level
2	The sum of ranks is from 10 to 23 points	In the area PT&PMA professional competences are created at the medium level
3	The sum of ranks is from 24 to 81 points	In the area PT&PMA professional competences are created at the basic level
4	The sum of ranks is more 82 points	In the area PT&PMA professional competences are created At the high level

Determination of level of formation of competences of the bachelor of STI in experimental and research activity

Requirements of FSES HE and their detailed specification for bachelors of BI in the field of the experimental and research activity (E&RA) are presented in tab. 13.

Table 13

The regulated FSES HE the list of competences of the bachelor of BI in experimental and research activity

The list of the competences regulated by FSES HE in the field of E&PA	The graduate shows:	Appointed ranks
PC-13: knows scientific and technical information, domestic and foreign experiment on an activity profile	Knowledge of scientific and technical information on an activity profile at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	Knowledge of domestic and foreign experiment on an activity profile at a low level	5

The list of the competences regulated by FSES HE in the field of E&PA	The graduate shows:	Appointed ranks
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-14: possession of methods and means of physical and computer modeling with use of universal and specialized program computer systems	Possession of methods and means of physical and computer modeling with use of universal and specialized program computer systems at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-14: possession of methods and means of physical and computer modeling with use of systems of automation of design (SAD)	Possession of methods and means of physical and computer modeling with use of SAD at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-14: possession of methods and means of physical and computer modeling with use of standard packages of automation of researches	Possession of methods and means of physical and computer modeling with use of standard packages of automation of researches at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-14: possession of test methods of building constructions and products	Possession of test methods of building constructions and products at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-14: possession of methods of statement and carrying out experiments by the set techniques	Possession of methods of statement and carrying out experiments by the set techniques at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-15: it is capable to make reports on the performed works	Ability to make reports on the performed works at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-15: it is capable to participate in introduction of results of researches	Ability to participate in introduction of results of researches at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-15: it is capable to participate in practical developments	Ability to participate in practical developments at a low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12

STEP 1. Let's describe pedagogical process of formation of competences of bachelors of BI in experimental and research activity by means of attributes and signs corresponding to them. Results of this step are presented in the left and medium columns of tab. 13.

STEP 2. Let's appoint to signs of attributes of the studied process ranks. Results of this step are presented in the right extreme column in tab. 13. Let's write out values of the appointed ranks in tab. 14.

STEP 3. Let's make the procedure of standardization of ranks which results are presented in tab. 15. As a result of carrying out standardization of ranks we have received the function set tablichno (tab. 16).

STEP 4. Let's construct the schedule of this function on a piece [1,12] (fig. 3).

Table 14

Values of the appointed ranks to attributes process of formation of competences of the bachelor of STI in the field of experimental and research activity

No. attribute E&RA	Appointed ranks											
1 PC-13	1	2	3	4	5	6	7	8				
2 PC-14	1	2	3	4								
3 PC-14	1	2	3	4	5	6	7	8				
4 PC-14	1	2	3	4	5	6	7	8				
5 PC-15	1	2	3	4	5	6	7	8	9	10	11	12

Table 15

Values of the standardized ranks on signs of attributes of process of formation of competences of the bachelor of BI in the field of experimental and research activity

No. attribute E&RA	Min	Standardized ranks										Max
1	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
2	1	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	0,25	4
3	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
4	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
5	1	2	3	4	5	6	7	8	9	10	11	12
Av.val.	1	0,87	1,07	1,27	1,47	1,67	1,87	2,07	2,27	2,47	2,67	8

Table 16

Table valued function for determining level of formation of professional competences of bachelors of BI in the area E&RA

X	1	2	3	4	5	6	7	8	9	10	11	12
У	1	0,68	0,93	1,18	1,43	1,68	1,93	2,18	2,43	2,68	2,93	3,18

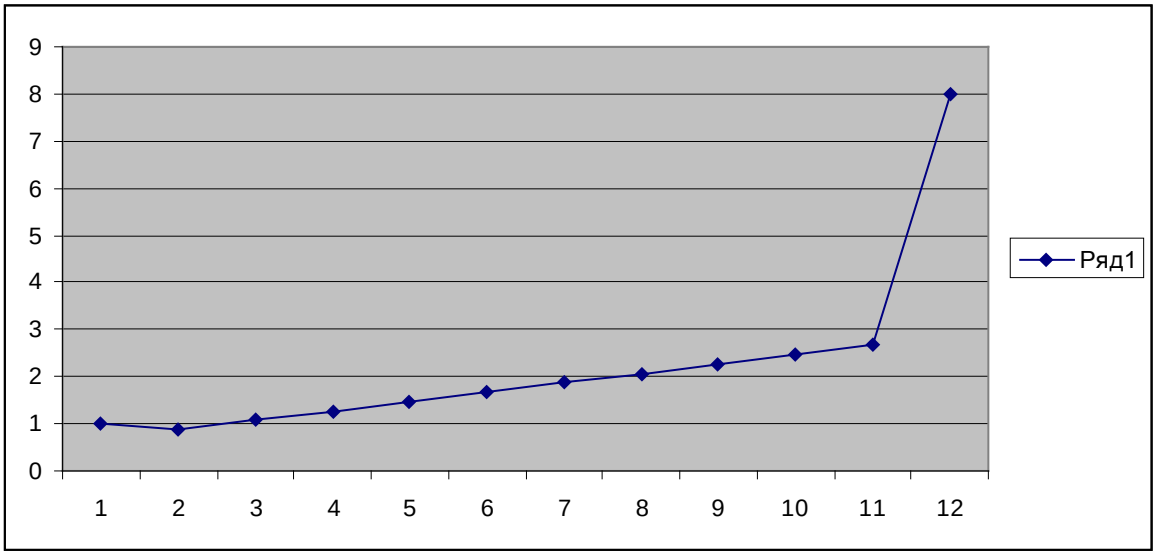

Figure 3. The schedule of change of medium values of ranks when determining level of formation of competences of bachelors of BI in the field of experimental and research activity

In fig. 3 follows from the schedule that the interval [1,12] breaks border points 2, 3 and 11 into 4 areas. The result of recalculation of border points for definition of estimated intervals is presented in tab. 17.

Table 17

Results of recalculation of values of border points in estimated intervals when determining level of formation of competences of bachelors of BI in experimental and research activity

Values boundary ranks	% of values boundary ranks from the maximum quantity of ranks (12)	Sum of ranks, corresponding to border points (from the sum of the maximum ranks (40)	Estimated Interval
2	17	7	$1 \le \sum \le 7$
3	25	10	$8 \le \sum \le 10$
11	92	37	$11 \le \sum \le 37$

Now it is possible to formulate estimated intervals for determination of level of formation of competences of bachelors of STI in experimental and research activity which are presented in tab. 18.

Table 18

Levels of formation of competences of bachelors of BI in experimental and research activity

No.	Sum of ranks	Recommendations of the expert
1	The sum of ranks is less than8 points	In the area E&RA professional competences are created at a low level
2	The sum of ranks is from 9 to 10 points	In the area E&RA professional competences are created at the medium level
3	The sum of ranks is from 11 to 37 points	In the area E&RA professional competences are created at the basic level
4	The sum of ranks is more 37 points	In the area E&RA professional competences are created at the high level

Determination of level of formation of competences of the bachelor of BI in assembly and adjustment and service and operational activity

The requirements of FSES HE for bachelor of BI and detailed details of them in the field of assembly and adjustment and service and operational activities (AA & SOA) are presented in Table 19.

Table 19

The list of professional competences of the bachelor of BI In the field of assembly and adjustment and service and operational activities

The list of the competences regulated by FSES HE in the field of AA&SOA	The graduate shows:	Appointed Ranks
PC-16: knowledge of the rules and technology of installation, commissioning, testing and commissioning and operation of structures, engineering systems and equipment of construction sites, objects of housing and communal services	Knowledge of the rules and technology of installation of structures, engineering systems and equipment of construction sites, housing and utilities objects at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
	Knowledge of the rules and technologies for adjusting structures, engineering systems and equipment of construction sites, housing and communal services at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-16: knowledge of the rules for accepting samples of products manufactured by the enterprise	Knowing the rules for accepting samples of products produced by an enterprise at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-17: knowledge of methods of testing equipment and tools	Possession of methods of experimental testing of equipment and technological support at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-18: knowledge of methods for monitoring and assessing the technical condition and residual life of construction sites and utilities, construction and housing-communal equipment	Possession of methods for monitoring and assessing the technical condition and residual life of construction sites and housing-communal equipment at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC18: knowledge of methods for monitoring and assessing the technical condition of construction and housing	Possession of methods for monitoring and assessing the technical condition of construction and housing - communal equipment at a low level	5
	At the medium level	6
	At the basic level	7

The list of the competences regulated by FSES HE in the field of AA&SOA	The graduate shows:	Appointed Ranks
- communal equipment	At the high level	8
PC-19: knows the basics of the organization of preventive examinations, repairs, acceptance and development of the introduced equipment	Ability to organize preventive inspections, repairs, acceptance and development of the introduced equipment at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-19: knows the basics of making requests for equipment and spare parts	Knowing the basics of making requests for equipment and spare parts at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-19: is able to prepare technical documentation and instructions for operation and repair of equipment, engineering systems	Ability to prepare technical documentation and instructions for operation and repair of equipment, engineering systems at a low level	9
	At the medium level	10
	At the basic level	11
	At the high level	12
PC-20: knows the basics of organization and planning of technical operation of buildings and structures, housing and utilities objects in order to ensure reliability, economy and safety of their operation	Ability to organize and plan technical operation of buildings and structures, housing and utilities objects to ensure reliability, economy and safety of their operation at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4

STEP 1. We describe the pedagogical process of forming the competencies of BI bachelors in the field of assembly and adjustment and service and operational activities with the help of attributes and their corresponding characteristics. The results of this step are presented in the left and middle columns of Table. 19.

STEP 2. Assign attributes of the attributes of the process being studied to the ranks. The results of this step are shown in the rightmost column in Table. 19.

Let us write down the values of the assigned ranks in Table 20.

Table 20

Values of assigned ranks to attributes process of formation of Bachelor's competences in BI in the field of assembly and adjustment and service and operational activities

No. attribute AA&SOA	Appointed ranks											
1 ПК-16	1	2	3	4	5	6	7	8				
2 ПК-16	1	2	3	4								
3 ПК-17	1	2	3	4								

4 ПК-18	1	2	3	4	5	6	7	8				
5 ПК-19	1	2	3	4	5	6	7	8	9	10	11	12
6 ПК-20	1	2	3	4								

STEP 3. We perform the procedure for standardizing the ranks, the results of which are presented in Table. 21.

Table 21

Values of Standardized ranks on the basis of attributes of the process of forming competences Bachelor of BI in the field of assembly and adjustment and service and operational activities

No. attribute AA&SOA	Min	Standardized ranks										Max
1	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
2	1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	4
3	1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	4
4	1	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	0,7	8
5	1	2	3	4	5	6	7	8	9	10	11	12
6	1	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	0,3	4
Av.val.	1	0,72	0,88	1,05	1,22	1,38	1,55	1,72	1,88	2,05	2,22	6,67

As a result of the standardization of ranks, we obtained a function, given in tabular form and presented in Table 22.

Table 22

Table valued function for determining level of formation of professional competences of bachelors of BI in the area AA&SOA

X	1	2	3	4	5	6	7	8	9	10	11	12
У	1	0,72	0,88	1,05	1,22	1,38	1,55	1,72	1,88	2,05	2,22	6,67

STEP 4. We will construct a graph of this function on the interval [1,12] (Fig.4).

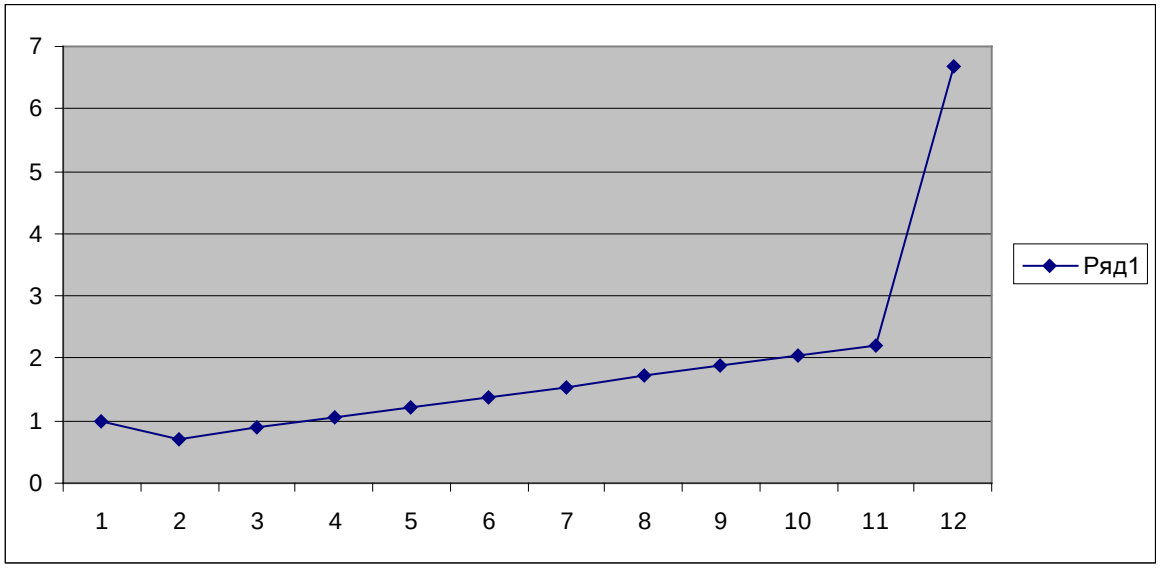

Figure 4. The graph of the change in the average values of ranks in determining the level of competence of bachelor's degree in the field of assembly and adjustment and service and operational activities

From the graph in Fig. 4 it follows that the interval [1,12] is divided by boundary points 2, 4 and 11 into 4 regions. The result of the recalculation of the boundary points to determine the estimated intervals is shown in Table. 23.

Table 23

Translation results values of boundary points in the estimated intervals when determining the level of competence of bachelor's competences in BI in the field of assembly and adjustment and service and operational activities

Values boundary ranks	% of values boundary ranks from the maximum quantity of ranks (12)	Sum of ranks, corresponding to border points from the sum of the maximum ranks (40)	Estimated Interval
2	17	7	$1 \le \sum \le 7$
4	34	14	$8 \le \sum \le 14$
11	92	37	$15 \le \sum \le 37$

Now it is possible to formulate the final evaluation intervals for determining the level of the competence of the bachelors of the BI in the field of assembly and adjustment and service and operational activities , which are presented in Table. 24.

Table 24

Formation levels professional competences of bachelors of BI in the field of assembly and adjustment and service and operational activities

No.	Sum of ranks	Recommendations of the expert
1	The sum of ranks is less than 7 points	In the area AA&SOA professional competences are created at a low level
2	The sum of ranks is from 8 to 14 points	In the area AA&SOA professional competences are created at the medium level
3	The sum of ranks is from 15 to 37 points	In the area AA&SOA professional competences are created at the basic level
4	The sum of ranks is more 37 points	In the area AA&SOA professional competences are created At the high level

Determination of the level of competence of bachelor's degree in BI in the field of business activity

The requirements of the FSES HE for bachelors of BI and detailed details of them in the field of business activity (BA) are presented in Table 25.

Table 25

List of professional competencies of the bachelors of BI in the field of business activity

The list of the competences regulated by FSES HE in the field of BA	The graduate shows:	Appointed ranks
PC-21: knowledge of the fundamentals of pricing in construction and	Knowledge of the fundamentals of pricing in construction and housing and utilities at a low level	1
	At the medium level	2
	At the basic level	3

housing and utilities	At the high level	4
PC-21: knowledge of the basics of budgetary rationing in construction and housing and utilities	knowledge of the basics of budgetary rationing in construction and utilities at a low level	5
	At the medium level	6
	At the basic level	7
	At the high level	8
PC-21: able to develop measures to increase the technical and economic efficiency of construction organizations and housing and communal services organizations	The ability to develop measures to increase the technical and economic efficiency of construction organizations and housing and communal services organizations at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-22: the ability to develop measures to increase the investment attractiveness of construction sites	The ability to develop measures to increase the investment attractiveness of construction sites at a low level	1
	At the medium level	2
	At the basic level	3
	At the high level	4
PC-22: the ability to develop measures to increase the investment attractiveness of housing and communal services	The ability to develop measures to increase the investment attractiveness of housing and communal services at a low level	
	At the medium level	2
	At the basic level	3
	At the high level	4

STEP 1. We describe the pedagogical process of forming the competences of BI bachelors in the field of business activity with the help of attributes and the corresponding features. The results of this step are presented in the left and middle columns of Table. 25.

STEP 2. Assign attributes of the attributes of the process which is being studied to the ranks. The results of this step are shown in the right column in Table. 25.

Let us write down the values of the assigned ranks in Table 26.

Table 26

Values of the assigned ranks to the attributes of the process of forming the competencies of the BI bachelors in the field of business activity

No. attribute BA	Appointed ranks							
1	1	2	3	4	5	6	7	8
2	1	2	3	4				
3	1	2	3	4				
4	1	2	3	4				

STEP 3. We perform the procedure for standardizing the ranks, the results of which are presented in Table. 27.

Table 27

Values of Standardized ranks On the basis of attributes of the process of forming the competencies of the BI bachelors in the field of business activity

No. attribute BA	Min	Standardized ranks						Max
1	1	2	3	4	5	6	7	8
2	1	0,5	0,5	0,5	0,5	0,5	0,5	4
3	1	0,5	0,5	0,5	0,5	0.5	0,5	4
4	1	0,5	0,5	0,5	0,5	0.5	0,5	4
Av.val.	1	0,875	1,125	1,375	1,625	1,875	2,125	5

As a result of the standardization of ranks, we obtained the tabulated function given in Table 28.

Table 28

Table valued function for determining level of formation of professional competences of bachelors of BI in the field of business activity

X	1	2	3	4	5	6	7	8
У	1	0,875	1,125	1,375	1,625	1,875	2,125	5

STEP 4. Construct a graph of this function on the interval [1,8], (Fig.5).

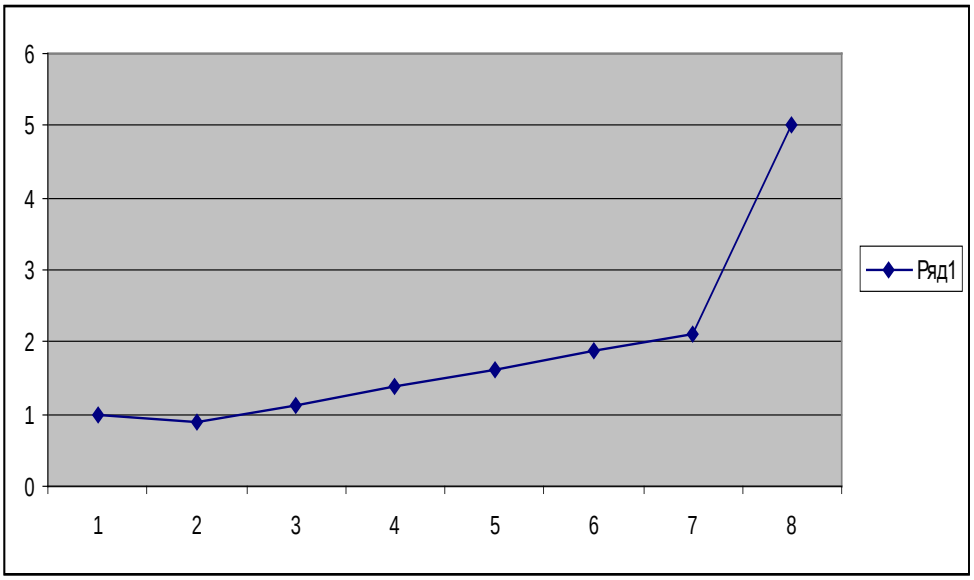

Figure 5. The graph of the change in the average values of ranks when determining the level of competence of BI bachelor in the field of entrepreneurial activity

It follows from the graph in Fig. 5 that the interval [1,8] is divided by boundary points 2, 3 and 7 into 4 regions. The result of the recalculation of the boundary points to determine the estimated intervals is shown in Table. 29.

Table 29

Results of conversion of boundary points values in the evaluation intervals when determining the level of BI bachelor competence in the field of business activity

Values boundary ranks	% of values boundary ranks from the maximum quantity of	Sum of ranks, corresponding to border points	Estimated Interval

	ranks (8)	(from the sum of the maximum ranks (20)	
2	25	5	$1 \leq \sum \leq 5$
3	37	8	$6 \leq \sum \leq 8$
7	87	17	$9 \leq \sum \leq 17$

Now it is possible to formulate the final evaluation intervals for determining the level of competence of bachelors of BI in the field of business activity, which are presented in Table 30.

Table 30

Levels of competency formation of bachelors of BI in the field of business activity

No.	Sum of ranks	Recommendations of the expert
1	The sum of ranks is less than 5 points	In the area BA professional competences are created at a low level
2	The sum of ranks is from 6 to 8 points	In the area BA professional competences are created at the medium level
3	The sum of ranks is from 9 to 17 points	In the area BA professional competences are created at the basic level
4	The sum of ranks is more 17 points	In the area BA professional competences are created At the high level

The application of the algorithm of the well-known mathematical method for standardizing ranks made it possible to calculate the estimated intervals for determining the levels of the formation of professional competencies regulated by the FSES HE in the direction of "Construction" training, for future bachelors-builders, namely in the prospecting and design activities, production and technological and production management activity, experimental and research activities, assembly and adjustment and service and operational activities and business activity.

Practical application of the developed mathematical model assumes the automation of the process of assessing the level of the formation of professional competence in a particular field of activity through the implementation in the form of an interactive software module and the development of special educational, methodological and control materials that allow the future bachelor-builder to demonstrate theoretical knowledge and skills, and practical experience in the research areas.

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