

Maryna Horna,
PhD in Economics,
SSI «Institute of Educational Analytics»,
E-mail: maryna.horna@kneu.edu.ua
ORCID: <https://orcid.org/0000-0002-6011-5753>;

Yaroslava Ishchuk,
Ph.D. in Economics,
Associated Professor of Department,
Kyiv National Economic University named after Vadym Hetman,
E-mail: Yaroslava.ischuk@gmail.com
ORCID: <https://orcid.org/0000-0003-1411-1716>

USING STATISTICAL METHODS TO ANALYZE EDUCATION

Abstract. Methods of statistical analysis, in particular sample surveys to monitor implementation of the Ukrainian education, are analyzed in the article. The topical issues that need to be addressed in evaluating secondary education reforms are outlined: the attitude of teachers belonging to all age categories to the reform of the Ukrainian education, the accessibility and effectiveness of professional development courses, the readiness to develop new educational programs, and the material equipment of classrooms depending on the type of area (urban or rural).

The aim of the article is to obtain relevant statistical data on education and sup up the experience of monitoring studies in education using a combination of statistical methods. The article is based on general scientific methods: analysis and synthesis, comparisons, analysis of contingency tables, graphical method, etc. The correlation between the teacher's age and his/her attitude to reform, the teacher's training and retraining and his/her ability and desire to master new teaching methods, material support of the educational process and the type of area was analyzed. The hypotheses about the correlation of variables and the agreement of the respondents' opinions were tested.

The practice of implementing monitoring studies to meet the demands of administrations in analytical information on education is discussed. It is emphasized that more effective statistical and information technologies, forms and methods of statistical observations, including special and sample surveys, need to be used in statistical studies as an alternative to the traditional reporting. The need for elaborating methodological and organizational issues in plans of particular surveys with consideration to information support and advanced Internet, information & communication and digital technologies is highlighted.

The end result of the study is to obtain statistically reliable data for analysis which results will enable to formulate conclusions and recommendations for actors of the educational process. The produced information can be useful for education authorities as the basis for taking administrative decisions.

Key words: analysis of Ukrainian education, survey sampling, sample design, monitoring studies, statistical criteria.

JEL Classification: C15, I21

Анотація. У статті проаналізовано можливості використання методів статистичного аналізу, зокрема вибірових опитувань, для моніторингу розвитку української освіти. Окреслено актуальні питання, на які необхідно звернути увагу в оцінці реформ середньої освіти: ставлення вчителів усіх вікових категорій до реформування української освіти, доступність та ефективність курсів підвищення кваліфікації, готов-

ність до розробки нових освітніх програм, матеріальне оснащення навчальних кабінетів залежно від типу місцевості (міська чи сільська).

Метою статті є отримання відповідних статистичних даних про освіту та узагальнення досвіду моніторингових досліджень в освіті з використанням комбінації статистичних методів. Стаття базується на загальнонаукових методах: аналізі та синтезі, порівняннях, аналізі таблиць контингентності, графічному методі тощо. Досліджено співвідношення віку вчителя та його ставлення до реформування, підготовки та перепідготовки вчителя та його здібностей. Проаналізовано бажання оволодіти новими методами навчання, матеріальне забезпечення навчального процесу за напрямками навчання. Було перевірено гіпотези про кореляцію змінних та збіг думок респондентів.

Обговорюється практика впровадження моніторингових досліджень для задоволення потреб органів управління в аналітичній інформації про освіту. Наголошується на необхідності використання спеціальних та вибіркового досліджень, як альтернативи традиційній звітності. Також обґрунтовано необхідність розроблення планів досліджень з урахуванням інформаційного забезпечення та можливостей мережі Інтернет, інформаційно-комунікаційних та цифрових технологій.

Кінцевим результатом дослідження є отримання статистично достовірних даних для аналізу, результати якого дозволять сформулювати висновки та рекомендації для суб'єктів освітнього процесу. Отримана інформація може бути корисною органам управління освітою як основа для прийняття управлінських рішень.

Ключові слова: аналіз української освіти, вибіркове опитування, дизайн вибірки, моніторингові дослідження, статистичні критерії.

Introduction. The educational statistic, administrative and analytical information is necessary to make managerial decisions of every level, to effectively form and carry out state policy in the sphere of education and science. Among the key aspects to improve the approach for the process of creating and using the educational statistics:

- increasing the number of sample (non-continuous) statistical observation;
- introduction of modern modeling methods;
- implementation of modern methods and technologies for collecting data;
- providing safe electronic collecting, analysis, storage, distribution of data, including paper media;
- enlargement of using administrative data [1, p. 11].

Methods for statistical analysis are widely used to detect and track the tendencies of education development in Ukraine. This way, in particular, the methodology of sample examinations and monitoring researches are used to track the tendencies of introducing the New Ukrainian School (hereinafter — NUS); the researches of the quality of educational process in preschool institutions under ECERS-3 method (Early Childhood Environment Rating Scale), which is performed by the Ukrainian development institution in the partnership with the Team for supporting reforms of the Ministry of education and science of Ukraine (MEU), the All-Ukrainian foundation “Step by step” and with the support of UNICEF in Ukraine; introduction of SELFIE instrument (Self-reflection on Effective Learning by Fostering the Use of Innovative Educational Technologies) in Ukraine; performing international evaluation of PISA students (Program for International Student Assessment) etc.

Among the key matters, necessary to resolve in the course of conducting reforms in general secondary education, the important are: attitude of teachers of different age towards NUS, the opportunity and the effectiveness of undergoing the advanced training courses, readiness to develop new educational programs and level of providing

classrooms with material resources both — in urban territory and in countryside.

Analysis of the latest researches and publications. A great amount of scientific and practical, as well as methodological nature are dedicated to statistical studies of education, in particular, secondary education. Among the native and foreign scientists the following attracted attention to this matter: A. Agranovych, N. Vashchayeva, S. Gerasimenko, I. Gonchar, L. Hochberg, I. Kalachova, L. Kovalenko, R. Kulynych, S. Londar, O. Osaulenko, N. Parfentseva and others. A great practical contribution into development of methodological aspects for introducing NUS in Ukraine and its regions was made by T. Biloglib, L. Grynevych, O. Denysiuk, L. Kozarezenko, L. Parashchenko, N. Tytarenko, V. Tkachenko, V. Shestak and other scientists. Together with this, the matters of holding statistical researchers of NUS introducing tendencies with the purpose of widening the informational and statistical base, its filling with new parameters, introducing new methods for collecting information stay unresolved in the scientific literature.

The need of resolving these matters stipulated the choice of the research and its goal wording. **The goal if the research** is obtaining relevant statistical data about NUS introduction, generalization of experience for performing monitoring researches in education with the use if statistic methods combination.

Monitoring of education research is the system for consistent, continuous and systematic measures, to be performed with the purpose of detecting and tracking the tendencies of education development, the effectiveness of introducing reforms in the country on the whole, in certain regions, in educational establishments (other educational activity entities), establishment of conformance to the actual findings of the educational activity with the goals set, as well as evaluation of the extent, the approach and the reasons for deviations from these goals [2–7]. In order to perform monitoring as a method for collecting information questionnaires are used, and, taking into account the epidemiological situation — online questionnaires with the help of Google Forms. The major advantage of this method is the possibility of remote collecting of data and absence of the need to print paper questionnaires [3, p. 10]. After performing questionnaire within the framework of selective examination the following types of editing the obtained data sets are used, like correcting errors and imputation (a technological operation, the sense of which is in establishing and inputting the criteria for specific data elements, in respect of which there are no answers or answers may not be used). Let us state, that the authors of the article joined the team of experts of the State scientific establishment “Institute of educational analytics”, who performed the all-state monitoring research of NUS reform introduction [3], at the stage of analysis of the findings of questionnaires performed.

Findings and discussions. *Characteristics of sample research design.* Formation of sampling basics and its design is based on the modern scientifically grounded principles for performing sample observations, the national and international experience of similar examinations. More often to select schools a combined multilevel sampling is used: I level — stratified, II level — random taking into account the region, type of settlement, type of general secondary educational establishment; to sample teachers and parents — single level, random (except for the abovementioned references, methodological aspects of sampling, performing examination and processing the findings have been studied in publications [8–12]).

The amount of sampling is established taking into account two major factors: 1) the necessary reliability of examination findings (threshold variation coefficient value); 2) the amount of resources, first of all, financial and labor, which may be engaged to perform examination. The value of variation coefficient is established pursuant to the requirements concerning the quality of the value assessment. For example, in order to track the tendencies in the implementation of the NUS reform, it is advisable to settle the sample amount on the basis of estimating the shares of units that have a certain characteristic. In examination the lowest level of aggregation of the data is the level of the territory. At this level, the indicators will be evaluated with the lowest level of reliability. Therefore, it is advisable to base this determination on the required sample amount. According to the existing recommendations, the reliability of definition of indicators at a level that allows them to be used in the analysis should not be higher than 10 %. The direct selection of general secondary educational establishments takes place with the help of method Probability proportional to size, i.e. with the probability, proportional to the size, where the number of children in kinder gardens is used as the size (in particular [12–15]). The sampling accumulation is formed on the basis of database of educational establishments in SIES/AICEM (State informational educational system / Automated complex for educational management), which covers totally 14 815 establishments of full-time education. After calculation of the necessary number of sampling units from each entity (administrative unit, type of territory and type of educational establishment), selection of establishment was performed with the help of statistical program SPSS [3, c. 10].

With the purpose to observe the structure of general accumulation the system of weighing coefficients was implemented. Under the sampling scheme realized in the course of examination the system of weighing coefficients includes the coefficient of taking into account the real level of participation in the examination and the coefficient of taking into account additional external sources of information, in particular, the data of SIES/AICEM [3, p. 10].

Statistical criteria. According to the results of questionnaire performed in SPSS program hypotheses are checked concerning interlinks of features, tables are formed for mutual conjugation (stochastic connection analysis information base) and statistical criteria are calculated χ^2 and Fisher criterion, correlation of chances, Kramer and Chuprov coefficient of mutual conjugation, as also coordination of thoughts of respondents is analyzed with the help of Spearman's rank correlation coefficient ρ and concordance coefficient. For attributable features implementation of Jaccard index is possible. Structural changes in dynamics are estimated using linear or quadratic coefficients of structural shifts and integral coefficients of structural shifts by Salai or Gatev. Analytical possibilities of summarizing, grouping, and visualization capabilities with the help of summarized tables and charts Microsoft Office Excel and Power BI are widely used.

In the course of performing researches the issue of influence of the teachers' age at their attitude towards NUS was resolved. Under the results of two pilot questionnaires conducted with teachers in respect of attitude towards the new State Standard of primary education (SSPE) the tables of mutual conjugation are formed (table. 1, made by the authors).

Table 1

**ALLOCATION OF ANSWERS CONCERNING ATTITUDE TOWARDS
THE NEW STATE STANDARD OF PRIMARY EDUCATION ACCORDING
TO THE AGE OF THE RESPONDENTS, 2017/2018 ACADEMIC YEAR**

Age, years	What is your attitude towards introduction of the new SSPE?					
	Pilot 2017			Pilot 2018		
	I fully approve	I partially approve	Totally	I fully approve	I partially approve	Totally
Under 30	4	10	14	10	6	16
31–40	9	25	34	29	11	40
41–50	22	42	64	58	18	76
51–60	14	13	27	36	11	47
60+	1	–	1	1	–	1
Totally	50	90	140	134	46	180

To check the hypotheses as to interlinks of the age of respondents and their attitude towards the new State standard of primary education χ^2 is calculated. As compared to the conditional allocations of answers of the respondents (teachers) and unconditional is carried out with the help of χ^2 -allocation by Pearson, therewith the empiric values χ^2 calculated by the authors made 6,49 (2017) and 1,88 (2018). As the actual values of χ^2 do not exceed $\chi^2_{0,95}(4) = 9,49$, the zero hypotheses about absence of stochastic connection is not objected, i.e. with the possibility of 3 0,95 the link between the age of the respondents and the critical attitude towards the new State standard of primary education is insignificant. At the position of the actual both — in Ukraine and in the whole world the issue of ageism (age discrimination) the result of checking the hypothesis is received (without rejection of zero hypothesis), in the position of the authors, is a positive summary of the research.

Shifting to new standards of primary education requires due preparation of teachers. With this purpose in the EdEra platform, it is in particular created an online-course for teachers of primary school, within the framework of which their familiarization with the new SSPE takes place as well as with the methods of competent studies. This is one of the compulsory stages in advanced training of teachers. Analysis of the allocation of teachers' responses in 2018 (Table 2, made by the authors) showed that in the case of EdEra training, the probability of a positive attitude of respondents towards the new SSPE increases almost threefold (chances ratio $W = 2,69$).

The empiric value $\chi^2 = 7,06$ is more than the critical $\chi^2_{0,95}(1) = 3,84$, this way, with the probability of 0,95 the link between passing by the teachers of online-courses and their attitude towards the new State standard of primary education is recognized as significant. Therewith the calculated coefficient value of mutual conjugation by Chuprov $C = 0,3$ says about the moderate link between the features. This way, it is

possible to conclude that the attitude of teachers towards introduction of the new State Standard of Primary Education is more significantly influenced by other factors.

Table 2

**ALLOCATION OF TEACHERS' ANSWERS AS TO ATTITUDE TOWARDS
THE NEW STATE STANDARDS OF PRIMARY EDUCATION UNDER PASSING TRAINING
AT EDERA, OVER 2017/2018 ACADEMIC YEAR**

Did you/do you pass the online-course for teachers of primary school at EdEra?	What is your attitude towards introducing the new SSPE?		
	I fully approve	I partially approve	Totally
Yes	110	29	139
No	24	17	41
Totally	134	46	180

The interrelations between teachers' training at EdEra, the use of materials from the New Ukrainian School website, the support of a trainer-consultant during the implementation of the experiment and the readiness to develop their own educational programs are analyzed. Allocation of answers of teachers in 2018 gives the grounds to consider with the probability of 0,95 about availability of moderate stochastic link between passing the training at EdEra and the readiness to develop the own educational programs. The rest of educational events (using materials from the New Ukrainian School website, the support of a trainer-consultant during the implementation of the experiment) no significance of statistic criteria values received are justified *p-value*.

Approval of evaluation by the teachers of different age groups of effectiveness of educational programs are analyzed with the help of multiple rang correlation coefficient — concordance coefficient *K* (Table 3, made by the authors).

Table 3

**ALLOCATION OF ANSWERS OF TEACHERS IN RESPECT OF EVALUATION
OF EFFECTIVENESS OF PROFESSIONAL DEVELOPMENT FORMS ACCORDING
TO THE AGE, 2017/2018 ACADEMIC YEAR**

Evaluation of effectiveness of professional development forms, Grades from 1 to 5	Age, years					
	До 30	31–40	41–50	51–60	60+	Totally
2	–	1	–	–	–	1
3	–	2	5	1	–	8
4	5	13	23	11	–	52
5	11	24	48	35	1	119
Totally	16	40	76	47	1	180

Evaluation of respondents of different age groups, given in table 3, are under agreement, so with the probability of 0,95 there are grounds to believe that the value of the concordance coefficient of 0,869 is not random.

The allocation of teachers' answers as to the assessment of forms of professional development (seminars, workshops, business meetings, trainings, mentoring and other teachers' lessons) in 2017/2018 academic year and readiness to develop their own educational programs was analyzed using criteria χ^2 and coefficients of mutual conjugation by Kramer (C_K) and Chuprov (C_{ψ}). The findings of the analysis indicate the moderate link between the willingness to develop their own programs and attendance by the teachers of various educational events, and calculated for each form of professional development (seminars, workshops, business meetings, trainings, etc.) these statistical criteria testify to (with the probability of 0,95) the presence of a significant link between the features. Among the mentioned links, attending master classes and trainings is a more noticeable influence.

To evaluate the state of material support of implementation of the program of transition to the new standards of primary school, a sample survey of school principals was conducted. According to the findings of the principals survey within the third pilot stage of the New Ukrainian School in the SPSS package, tables of mutual conjugation were formed (Table 4, made by the authors).

Table 4

**ALLOCATION OF ANSWERS OF THE PRINCIPALS CONCERNING THE EXTENT
OF CONFORMANCE OF CLASSROOMS EQUIPMENT TO THE REQUIREMENTS
OF THE NEW STATE STANDARD OF PRIMARY EDUCATION ACCORDING TO THE TYPE
OF THE TERRITORY, OVER 2017/2018 ACADEMIC YEAR**

Type of settlements, where the educational establishment is located	Equipment of classrooms fully conforms to the requirements of the new SSPE				
	Does not conform	Partial nonconformance	Partial conformance	Fully conforms	Totally
City	1	13	26	21	61
Urban village	–	1	5	6	12
Village	–	1	10	3	14
Totally	1	15	41	30	87

On the basis of analysis performed with the use of SPSS pack and the calculated statistical criteria F and χ^2 the conclusion is made that with the probability of 0,95 there are no grounds to accept the hypothesis concerning the interrelations between the type of settlement, where the educational establishment is located, and the extent of conformance of the equipment of classrooms to the requirements of the new SSPE. The majority of principals states that equipment of classrooms fully or partially conforms to the requirements of the new SSPE. The essence of differences of the analyzed characteristics in urban villages is not certified statistically.

Similarly, on the basis of answers of principals within the framework of the third pilot stage of the New Ukrainian School in SPSS pack the tables of mutual conjugation under the type of settlement where the educational establishment is located are formed, and the level of provision of the educational process with funds.

Table 5

ALLOCATION OF ANSWERS OF PRINCIPALS IN RESPECT OF THE EXTENT FOR PROVISION OF EDUCATIONAL PROCESS UNDER THE TYPE OF SETTLEMENT WHERE THE EDUCATIONAL ESTABLISHMENT IS LOCATED, OVER 2017/2018 ACADEMIC YEAR

Type of settlement where the educational establishment is located	Evaluation of statement "Funds are enough to provide the educational process"				
	Totally disagree	Partially disagree	Partially agree	Totally agree	Totally
City	5	17	30	9	61
Urban village	–	3	3	6	12
Village	1	2	7	4	14
Totally	6	22	40	19	87

The values of statistical criteria F and χ^2 calculated in SPSS pack testify to the fact that the hypothesis concerning the interrelation of the type of settlement, where the educational establishment is located, and the extent of provision of the educational process with the funds is not certified. The majority of principals state that the funds to provide the educational process are fully or partially enough. The significance of differences of the extent of provision with funds in urban villages is not statistically certified. With the help of Spearman range correlation coefficient the correspondence of evaluation by principals of the conformance of the equipment in classrooms to the requirements of the new SSPE and provision of the educational process with funds is studied. It is detected that answers of principals are fully agreed; with the probability of 0,95 there are grounds to state that the values of Spearman range correlation coefficient $\rho = 0,998$ is not random. The correspondence of the thoughts of principals and teachers concerning financial provision is impossible to evaluate, as there is no information concerning answers of principals and teachers for every school, and the variants of answers to the same questions concerning material provision in the questionnaires for principals and teachers are different.

Conclusions. To meet the needs of management in analytical information about education, new, alternative to traditional reporting and more effective statistical and information technologies, forms and methods of statistical observation are introduced into the practice of statistical research. Currently, the system of statistical observations is mostly organized in the form of special surveys, including non-continuous ones. That is why it is extremely important to develop program-methodological and organizational issues of the plan of specific surveys in view of the possibilities of information support and modern Internet, ICT and digital technologies. The study allowed us to draw the following conclusions:

- the age of the teacher does not affect his attitude towards implementation of NUS reforms. In our opinion, experience and motivation to join innovations will be more important;
- reeducation and retraining of teachers is certainly an important factor influencing their ability and desire to master new teaching methods. Among the most effective teaching methods, teachers themselves choose to attend master classes and trainings;

– the NUS state support program is built rather proportionally to the allocation of funds depending on the type of area. The survey of principals showed no significant differences between the provision of schools in cities and villages.

Recommendations concerning approaches of education statistics development. The scientific community and experts in the field of education statistics have identified a number of priority issues that need to be addressed quickly. The important aspects are the following: providing access to up-to-date statistical data to all parties; integrated use, ensuring compatibility and comparability of entries in state registers; creation of a single open data portal with services convenient for different users; further implementation of the principles of electronic government in the field of education and expansion of the range of relevant information services to be provided to all parties. In order to reform state statistics in general to meet the current needs of society in objective, reliable and unbiased statistical information that meets the basic principles of official statistics approved by the UN General Assembly and the European Statistics Code, for sound decision-making, research and open discussions Resolution of the Cabinet of Ministers of Ukraine dated 27.02.2019 No. 222 approved the Program for the development of state statistics till 2023 [1, p. 11]. Some of its tasks relate to education statistics, namely:

1) Information support for monitoring the CSR, which stipulates the definition of the mechanism of information interaction between producers of statistical and administrative information necessary to monitor the Sustainable Development Goals till 2030 at the state level;

2) application of modern data collection technologies;

3) expanding the use of administrative data.

Implementation of the provisions of this Program stipulates improving the approach to the process of creating and using educational statistics. The key aspects are:

- reduction of the reporting burden on respondents who provide statistical and administrative data;

- application of modern methods and technologies of data collection, in particular with the use of national information systems; ensuring secure electronic collection, analysis, storage, dissemination of data, excluding paper;

- expanding the use of administrative data, including for decision-making at the regional level

– increasing the number of sample (non-continuous) statistical observations and the introduction of modern modeling methods;

- introduction of data collection and metadata for information monitoring of the Sustainable Development Goals at the state level;

- introduction of a quality management system in accordance with the requirements of the national standard DSTU ISO 9001: 2015 “Quality management systems. Requirements”;

- introduction of a process-oriented system of statistical information production [1, c. 11–12].

Government documents also emphasize the importance of using modern methods and technologies of statistical data collection, in particular with the use of national information systems, reducing the reporting burden on respondents, comparability of data with international statistics.

We consider the development of educational statistics, in particular the methodology of modernization of statistical reporting forms, improvement of technologies for collecting, processing and dissemination of statistical information in education, as well as development of methodological approaches to education management within the framework of the implementation of state policy in education based on evidence-based statistical data to be the priority approaches of further scientific researches.

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