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DATA VISUALISATION AS A TOOL FOR ENHANCING THE INFORMATIVE VALUE OF MONITORING STUDIES ON EDUCATION QUALITY

Abstract. *This article examines the critical role of data visualization in monitoring and analysing the implementation of education reform in Ukraine. It provides an in-depth exploration of how modern visualization tools enhance the effectiveness of monitoring studies related to educational reforms. Specifically, the study investigates advanced table-generation technologies, such as Google Sheets and Duet AI by Google, alongside data visualization tools, including artificial intelligence-based solutions. The material presents contemporary data visualization platforms, such as Tableau, Microsoft Power BI, and Google Charts, which enable interactive data analysis, the construction of charts, graphs, maps, and dashboards, and the identification of trends and patterns to support informed decision-making. Furthermore, the study emphasizes the significance of SPSS (Statistical Package for the Social Sciences) as a widely used statistical software for data analysis in social, medical, economic, and other research domains. SPSS facilitates the processing of large datasets, statistical computations, and visualization generation, making it a key tool for preparing monitoring reports in the education sector. Additionally, the article illustrates the application of data visualization methods in a monitoring study on the implementation of the New Ukrainian School (NUS) reform, conducted by the State Scientific Institution "Institute of Educational Analytics". The findings highlight the importance of modern data visualization techniques in analytical reports based on monitoring studies. Accurate and timely data representation enhances evidence-based decision-making, improves communication among stakeholders involved in the reform process, and enables prompt responses to emerging challenges. As a result, data visualization serves as a fundamental element in optimizing educational management, contributing to the effective implementation and long-term sustainability of the NUS reform.*

Keywords: *data visualisation, New Ukrainian School, monitoring study, general secondary education, educational reform.*

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In today's environment, reforming secondary education is a prerequisite for modernising the education sector, improving the quality of educational services, creating a safe educational environment and integrating Ukraine's education system into the European Education Area. The implementation of the New Ukrainian School (NUS) reform is one of the most important educational initiatives in Ukraine, aimed at creating a modern education system that meets the requirements of the times and promotes the comprehensive

development of learners. The main objectives of the NUS reform are to provide pupils with the necessary skills and competences for their future lives, to educate learners as innovators and citizens and to apply the pedagogy of partnership, i.e. cooperation between teachers, pupils and pupils' parents. The success of this reform depends on the clear and consistent implementation of changes at all levels of the educational process. This requires constant monitoring of various aspects of the reform, including the quality of education, teacher training, learning environment and learner achievement.

One **key tool for effectively tracking change implementation is establishing** feedback from reform participants through monitoring. A monitoring study should be conducted at regular intervals to record changes' dynamics. The results of monitoring are presented in the form of analytical reports. Such reports are generated by tabulating and visualising data based on the arrays of respondents' answers.

Building tables for visual representation of data in research is an important stage of information processing, as tables provide a structured and compact way to present results. The main features of table design include a clear definition of headings that reflect the essence of the indicators, adherence to common units of measurement for correct comparison of data, and a logical sequence of information presentation [1]. Data in tables should be organised in a way that facilitates their perception and analysis; tables are often accompanied by additional explanations or footnotes to clarify the values of indicators or methods of their calculation. The utilization of tables enhances data visibility and facilitates a comprehensive overview of general trends and interrelationships among indicators. This structured presentation is crucial for deriving accurate and well-founded conclusions in scientific studies [2].

Tables serve as a foundational tool for visualizing data through graphs and charts, enabling the representation of complex datasets in a structured and comprehensible manner. This approach enhances data interpretation, facilitates analytical processes, and supports informed decision-making. Due to visualisation, the educational community, government agencies and the public can get a clear picture of the progress of the reform and its impact on the participants in the educational process [3].

The problem of data visualisation was considered in the scientific works of C. Cantini, C. Chellini, M. Teresa Sagri [4], V. P. Mulyar, Y. A. Boyko, etc. In particular, V. P. Mulyar considers the theoretical foundations of data visualisation and infographics, the issues of building charts and graphs in Google Sheets and Google Analytics. The author also defined the basics of data visualisation in Google Data Studio and Microsoft Power BI [1]. In the works of Y. A. Boyko, the features of analytical tools R, SAS and SPSS are defined [5].

The purpose of this paper is to identify existing approaches to data visualisation and to justify the importance of using the latest methods of visual presentation of results when generating analytical reports on the results of monitoring studies of the NUS reform.

Data visualisation is one of the key elements of modern scientific research

that contributes to the understanding of complex phenomena and processes. It enables the effective presentation of large amounts of information, making it more accessible for analysis, interpretation and communication. With its ability to integrate multidimensional data into an easy-to-understand graphical format, visualisation helps to identify trends, discover patterns and formulate hypotheses.

The key principles of data visualisation are as follows [6]:

– a concise approach to texts, images, graphs;

– avoidance of information distortion;

– comparison of data on one graph or chart;

– choosing an adequate visualisation method (type);

– logical order of data presentation.

The field of data visualisation is constantly evolving to meet the challenges of the digital age. Innovative technologies, such as interactive platforms, three-dimensional graphics and artificial intelligence, provide new approaches to presenting information. For example, the use of machine learning algorithms allows data to be automatically structured and the best ways to present it visually.

In addition, methods of personalising visualisations are being improved, enabling graphs to be customised to meet the needs of specific user groups. This permits scientists to communicate more effectively with other disciplines and stakeholders, which enhances interdisciplinary collaboration and promotes informed decision-making.

Today, there is a wide range of data visualisation tools that are constantly improving and offering new features. Some of the most notable examples include (Table):

Tables are the fundamental basis for creating visualised materials. The tabular format is an effective method of visualising the results of a monitoring study. For example, in an analytical report, this data visualisation format is used to present information about groups, the number of survey

Table

Features of the leading data visualising tools

Tableau	A leading business intelligence and data visualisation platform that transforms complex information into understandable and interactive visual representations. It is designed to quickly analyse data and create charts, graphs, maps and dashboards to help users identify trends, patterns and make informed decisions. Tableau is also used in science and education to visualise research data and create educational materials.
Microsoft Power BI	It is a modern business intelligence platform that enables the interactive analysis and visualisation of data, and the creation of dashboards and reports that provide useful information for informed decision-making. It's part of the Microsoft system and integrates with many other products including Excel, Azure, SharePoint and Microsoft Teams. Power BI integrates with Excel, Teams, and Dynamics 365, facilitating organisations to combine data from multiple sources into a single platform, which is particularly effective for educational research.
Google Charts	It is a free web tool for creating interactive data visualisations that works on the basis of JavaScript and HTML5. It permits developers to integrate graphs and charts into web applications or websites, providing flexibility in design and interactivity. Due to its ease of use and integration with other Google products, Google Charts is a popular choice for data presentation. In the education sector, this tool is used to visualise statistical data and create interactive learning materials.

Created by the author according to the data: [7].

participants by region, and their characteristics.

Modern spreadsheet tools are constantly evolving, offering users new features and simplifying data management. The latest solutions include the following:

– *Google Sheets* is an online spreadsheet tool that is part of the Google Workspace system. It enables users to create spreadsheets, analyse data, collaborate in real-time, and integrate spreadsheets with other Google services such as Google Drive, Google Forms and Google Analytics.

– *Duet AI by Google* is an innovative artificial intelligence technology integrated into Google Workspace services. It is designed to increase productivity and simplify the work with documents, spreadsheets, presentations and other tools by offering intelligent assistance to users. Thanks to its generative AI capabilities, Duet AI automates routine tasks, improves collaboration, and helps you gain new insights [8].

The tabular materials are compiled on the basis of the processed data set, based on the results of the respondents' questionnaire. The processing of the data set includes checking the relevance of the data, coding it and, if necessary, weighting it. For this purpose, certain software packages are used, such as SPSS (Statistical Package for the Social Sciences).

SPSS is a data analysis software tool used in social, medical, economic and other research fields. It allows for the easy processing of data sets, the performance of statistical calculations and the creation of visualisations. SPSS supports a wide range of file formats, including Excel (.xls, .xlsx), CSV, text files, SQL databases, and SPSS's own save format (.sav). SPSS is a robust statistical software designed for handling large datasets, facilitating comprehensive analyses, and extracting meaningful insights essential for data-driven decision-making [5].

The main stages of processing a data set in SPSS include:

1. Data import. Data are imported in the form of tables, where rows are observations and columns are variables.

2. Data preparation. Coding of variables: assigning numerical codes to categories (e.g., 1 for male, 2 for female). Checking for missing values: SPSS can detect and handle missing data, such as replacing them with averages. Transforming variables: calculating new variables, recoding data, standardising.

3. Descriptive statistics. SPSS offers a wide range of tools for calculating basic characteristics of a data set, such as mean, median, mode, standard deviation, minimum and maximum values. This helps to get a general idea of the data distribution.

4. Statistical analysis. SPSS supports various methods of analysis: correlation analysis (identifying relationships between variables); regression analysis (estimating the dependence of the outcome variable on the factors); analysis of variation (determining differences between groups); factor analysis (reducing the number of variables and searching for latent factors); analysis of variance (identifying variability in data).

5. Data visualisation SPSS offers a wide range of graphical tools: bar charts, pie charts, boxplots, scatterplots. These graphs help to visualise the results of the analysis and facilitate data interpretation.

6. Interpretation of results. After performing the analysis, SPSS generates reports in the form of tables and graphs. Users can view the results through the

software interface or export them to formats such as Word, Excel, or PDF.

7. Data export. The processed data can be saved in various formats for further use. SPSS also supports integration with other applications, which makes it easy to transfer data between tools [5].

In general, data visualisation is an integral part of research. With the help of visualisation processes, researchers improve their ability to visually track changes in phenomena over time. Presenting information in a visual form with the help of graphs, charts and other images permits for a more accurate description of the results obtained, as well as identifying and tracking the most important trends.

Information visualization tools facilitate the effective communication of large datasets by presenting data in a clear and structured manner. Key visualization techniques include graphs (e.g., line, bar, pie), charts, heat maps, diagrams, and infographics, each offering distinct analytical capabilities. For instance, line graphs effectively illustrate temporal trends, whereas pie charts are suited for representing proportional relationships. Heat maps enable the rapid identification of areas with the highest concentration of specific indicators, making them particularly valuable in multivariate analyses. The selection of an appropriate visualization method should be guided by the nature of the data, the objectives of the study, and the informational needs of the target audience, thereby ensuring the accurate representation of findings and facilitating their interpretation.

Therefore, data visualisation in the context of monitoring studies plays a key role, as it enables to quickly and clearly convey information about changes, deviations or trends in the studied indicators. We can consider visualisation processes on the example of monitoring studies of the New Ukrainian School reform.

Since 2019, the implementation of the principles of the New Ukrainian School (NUS) [9] has been monitored through a nationwide monitoring study among participants in the educational process – principals, teachers, head teachers and pupils' parents. The survey of these groups is conducted using the Google Forms platform.

In the course of monitoring studies of the NUS reform, issues related to data visualisation were considered [10]. Among them:

– analysis of the role of data visualisation in the process of monitoring educational reforms, including the New Ukrainian School reform;

– identifying the main methods of data visualisation that contribute to improving decision-making in the education sector;

– evaluating the effectiveness of various data visualisation tools in the context of monitoring the implementation of educational innovations;

– to develop proposals for improving the use of data visualisation to ensure transparency and improve the quality of monitoring of the reform process;

– to formulate practical recommendations for education managers on the use of data visualisation tools in the practice of monitoring educational reforms.

The results obtained from the survey are processed using statistical software, and the data are then visualised.

In general, the main methods of data visualisation used in monitoring studies include:

– line graphs: used to illustrate the dynamics of changes in indicators over time, such as tracking changes in the level of material and technical support for NUS classrooms;

– bar and pie charts: these facilitate the comparison of indicator values across different categories or time periods;

– heat maps: used to show the intensity of phenomena in either a spatial or temporal context, such as tracking the number of internally displaced learners or teachers;

– dashboards: interactive platforms that integrate different types of graphs and tables to provide quick access to key information;

– geospatial maps: used to monitor geographically related processes, such as educational institutions opening or closing.

To generate reports on the results of monitoring studies of the NUS implementation, illustrative elements created in Microsoft Office Excel are predominantly used, with histograms being the primary tool for visualizing the findings.

A histogram is a certain ordered sequence of columns, each of which corresponds to a digit interval, and its height reflects the number of cases or frequencies in this digit [11]. A histogram shows the distribution of values in a set of objects.

For example, histograms can be provided from the monitoring study of the implementation of the NUS reform in pilot educational institutions (basic schools), conducted by the SSI "Institute of Educational Analytics" in 2023, can be provided [12]. In this case, the answers of the participants regarding the qualification category were presented in a horizontal chart without grouping (Fig. 1).

Fig. 1 presents a horizontal chart showing the percentage distribution of survey participants by qualification category. By sorting, it is possible to immediately and clearly identify the smallest and largest shares of respondents, along with their corresponding qualification categories.

A similar visualisation method is used for simple distributions of responses to questions in the socio-demographic block (age, gender, length of service, qualification category, etc.), as well as in the methodological, logistical, and other blocks.

Grouping histograms are used by researchers when grouping different respondent groups based on the same set of questions. For example, if a monitoring study involves principals, teachers from pilot schools, pupils' parents and NUS coordinators, grouping histograms can be used to show the age breakdown of survey participants (Fig. 2).

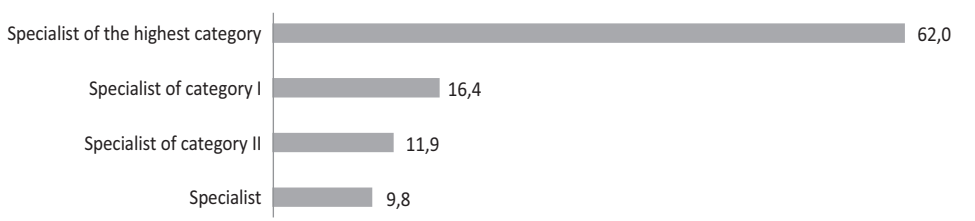

Fig. 1. **Distribution of survey participants by qualification category,** *%*
Constructed by the author based on: [12].

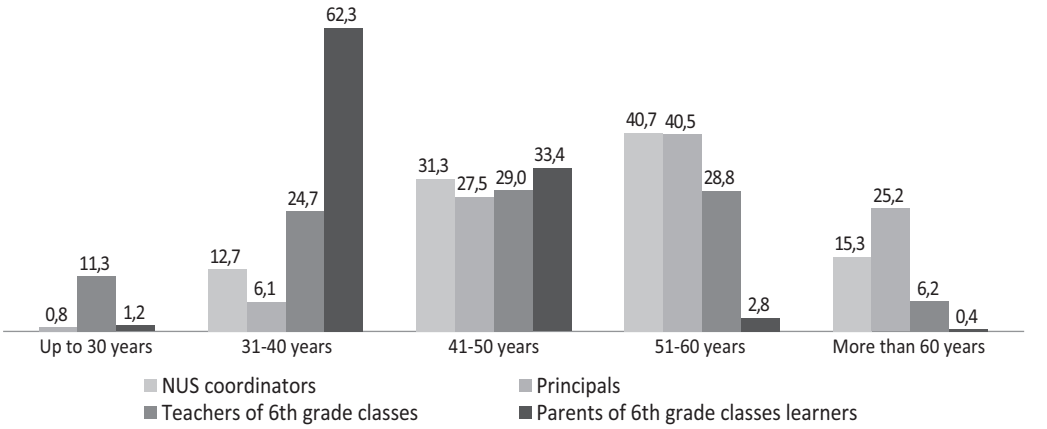

Fig. 2. **Distribution of survey participants by age,** *%*

Constructed by the author based on: [12].

In a similar way, it becomes possible to visually show the percentage of respondents by gender (Fig. 3).

Histograms are a clear example of the distribution of values within a set of objects. Histograms are always plotted starting from zero, with the horizontal axis representing the values and the vertical axis showing how many objects in the set correspond to each value. Grouping facilitates for comparing the proportion of respondents in each group.

Horizontal histograms with grouping are also a common method of visualising data in analytical reports of NUS implementation monitoring studies. They permit a clear visual representation of the distribution of objects by respective groups or percentage distribution.

Such histograms effectively present information with detailed text alternatives. Examples of such diagrams include the distribution of responses by the names of methodological materials used by teachers in pilot classes, resources and sources used by NUS coordinators (Fig. 4), the names of available material and technical support,

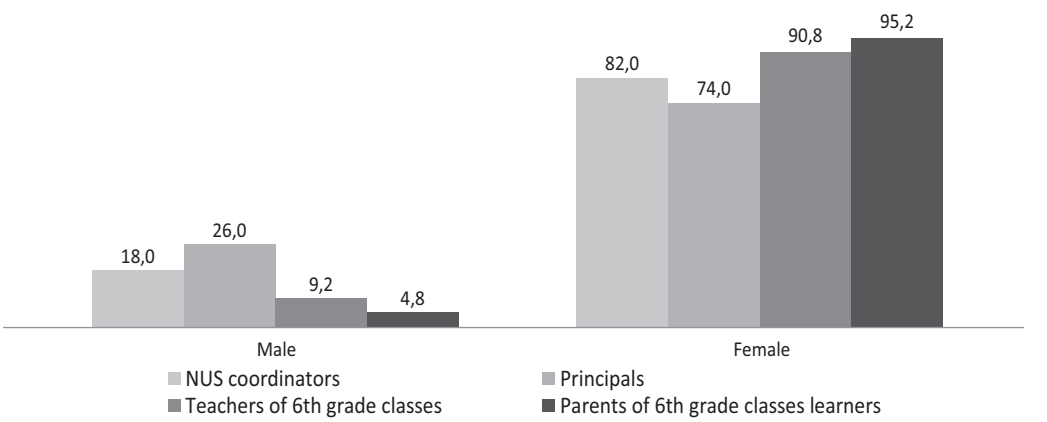

Fig. 3. **Distribution of survey participants by gender,** *%*

Constructed by the author based on: [12].

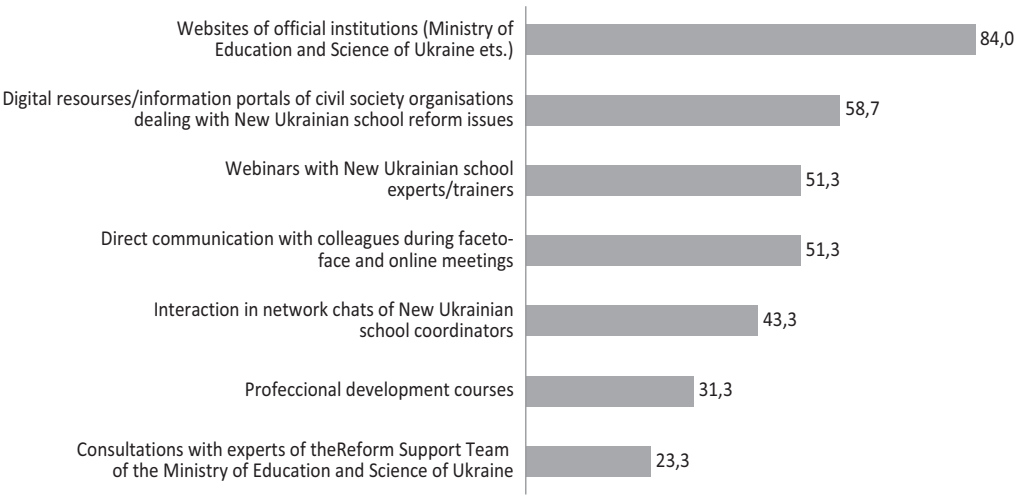

Fig. 4. **Distribution of responses of NUS coordinators regarding resources/sources with up-to-date information that they most often use to support their coordination activities,** *%*

Constructed by the author based on: [12].

and the level of damage to educational institutions during the full-scale war etc. (Fig. 5).

Fig. 4 shows a horizontal bar chart without grouping, which, through the proportional arrangement of alternative names, clearly illustrates the resources used by the NUS coordinators with detailed text labels.

Fig. 5 shows a grouped histogram depicting information about the condition of educational institutions as a result of hostilities, based on responses from two groups of participants: principals and 6th grade teachers. This visualization enables a comparison of answers to the same question from different respondent groups and enables an analysis of the results.

These types of diagrams are the most common form of data visualisation used in preparing analytical reports on the

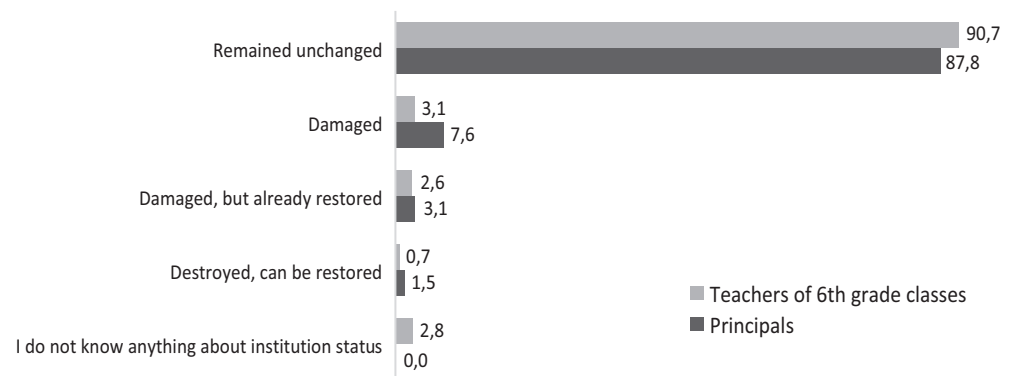

Fig. 5. **Distribution of survey participants by answers about the status of the educational institution,** *%*

Constructed by the author based on: [12].

results of monitoring studies related to the implementation of the NUS reform. When conducting monitoring studies on the implementation of the NUS reform, an important aspect is the correct visual presentation of the results. This is possible through various methods of data visualisation.

The visual presentation of information derived from monitoring studies serves as a crucial tool for enhancing the comprehension and analysis of large datasets. The use of graphs, charts, maps, and other visual elements facilitates the effective demonstration of dynamic changes, the identification of trends, and the exploration of relationships between variables, which may be less discernible in textual or tabular formats. This approach not only improves data interpretation but also contributes to a more systematic and insightful analysis of the study findings.

Effective visualization enhances the comprehension of research findings among both specialists and a broader audience with varying levels of expertise. Moreover, visual tools facilitate the rapid identification of trends, anomalies, and deviations in the monitored processes, thereby improving the efficiency of data-driven decision-making and enabling a timely response to emerging issues.

Taking into account the specifics of the preparation of analytical reports on the implementation of the NUS reform, the most common methods of data visualisation include the presentation of results in the form of horizontal and vertical bar charts with grouping and tables. In general, data visualisation is a key element in making an analytical report more informative, as it allows for a clear presentation of the results and the formation of analytical conclusions. However, further research into various forms and approaches to data visualisation, such as the creation of spatial images, is needed. This will permit for more effective use of methods of visualising research data in the education sector, increase the information content and improve the perception of the results of such studies.

Thus, data visualisation remains an important tool in scientific activities, and its continuous improvement and integration of innovative approaches create new opportunities for research and discovery. Data visualisation is an integral part of monitoring research, as it makes data more understandable and accessible for analysis. According to the use of modern technologies, researchers can more effectively monitor dynamic processes, make informed decisions and respond quickly to changes.

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ВІЗУАЛІЗАЦІЯ ДАНИХ ЯК ІНСТРУМЕНТ ПІДВИЩЕННЯ ІНФОРМАТИВНОСТІ МОНІТОРИНГОВИХ ДОСЛІДЖЕНЬ ЯКОСТІ ОСВІТИ

Анотація. *У статті підкреслено важливу роль візуалізації даних у моніторингу та аналізі впровадження освітньої реформи в Україні. Показано, як використання сучасних інструментів візуалізації підвищує ефективність моніторингових досліджень, пов'язаних з освітніми реформами. Зокрема, наведено переваги передових технологій створення таблиць, таких як Google Sheets і Duet AI від Google, а також інструментів візуалізації даних, включаючи рішення на основі штучного інтелекту. У статті розглянуто сучасні платформи візуалізації даних, як-от Tableau, Microsoft Power BI та Google Charts, що дають змогу проводити інтерактивний аналіз інформації, будувати діаграми, графіки, створювати карти й дашборди, а також виявляти тенденції та закономірності для прийняття обґрунтованих рішень. Окрім того, автор підкреслює важливість широко використовуваного статистичного програмного забезпечення SPSS (Statistical Package for the Social Sciences) для аналізу даних у соціальній, медичній, економічній та інших галузях досліджень. SPSS полегшує обробку великих масивів даних, проведення статистичних розрахунків і створення візуалізацій, що робить його ключовим інструментом підготовки моніторингових звітів в освітньому секторі. Також у статті проілюстровано застосування методів візуалізації даних на прикладі моніторингового дослідження впровадження реформи Нової української школи (НУШ), виконаного Державною науковою установою «Інститут освітньої аналітики». Результати дослідження засвідчили ефективність використання сучасних методів візуалізації даних в аналітичних звітах за результатами моніторингових досліджень. Адже точне й своєчасне надання інформації сприяє прийняттю обґрунтованих рішень, поліпшує комунікацію між зацікавленими сторонами, залученими до процесу реформування, та дає змогу оперативно реагувати на виклики, що виникають. Таким чином, візуалізація даних виступає фундаментальним елементом оптимізації управління освітою, сприяючи успішному впровадженню та довгостроковій ефективності реформи НУШ.*

Ключові слова: *візуалізація даних, Нова українська школа, моніторингове дослідження, загальна середня освіта, освітня реформа.*

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