

# The methodology of using information technology and visualisations to optimize and improve management in the effectiveness of a student's work in the laboratory

Anna Makarova<sup>1,\*</sup> and Elena Pavlicheva<sup>2</sup>

<sup>1</sup>Mendeleev University of Chemical Technology of Russia, UNESCO Chair 'Green Chemistry for Sustainable Development', 125042 Miusskaya sq. 9, Russian Federation

<sup>2</sup>MSUT "STANKIN", Office for the development of new educational technologies, 127055, Moscow, Vadkovsky lane, 3a, Russian Federation

**Abstract.** The United Nation has adopted the Sustainable Development Goals and goal No. 4 'Quality Education' is one of them. Information and communication technology transforms education at different levels. For the successful collection, system analysis and processing of large amounts of heterogeneous data, special tools were developed (including specialized indicators), algorithms (including the processing of statistical information in fields of nonparametric information to detect the presence of correlations between various factors) and databases. An example of the use of such indicators is a system for testing the effectiveness of a student's work in the laboratory. The initial assessment of the state of the laboratory was carried out using a sociological survey of persons associated with the organization of the educational process in the laboratory and subsequent data visualization. Which allowed us to determine that students and management perceive the state of the laboratory differently.

## 1 Introduction

The United Nation has adopted the Sustainable Development Goals and goal No. 4 'Quality Education' is one of them [1]. On the other hand, it should be noted that today we live in the age of digitalization, which is characterized by the emergence of large volumes of data [2,3], which must be properly structured, analysed and accurately presented so that citizens can be able to take advantage of these sets information. Modern education is the integration of content and learning technologies [4]. Information and communication technology transforms education at different levels. In all countries of the world there is an increase in the number of students remotely, the number of universities using them in the educational process is growing; a large number of international educational structures are being created, etc. currently, fundamentally new priorities are being identified in the educational sphere, the most important of which are the informatization of the management activities of educational organizations [4]. One of the levels at which Information and communication technologies have played a key role over the past three decades is the management and distribution of educational resources and the provision of data on students and teachers or professors, often called the "Education Management Information System".

Consequently, educational institutions were involved in the implementation of information systems and technologies that allow more efficient management of

their resources, at the same time, also allow students to actively interact with the entire field of their courses (professors, study materials, assessments and colleagues), which positively affects the effectiveness and success of both parties [5].

One of the functions of which is the use of data to support decision-making in the field of educational policy and the complexity associated with the entire process of education management, regardless of whether we analyse it from the point of view of students or from the point of view of an educational institution [6].

The modern education system in Russia often results in young people not choosing a direction in which they might be interested in studying and working in in the future, but instead choosing to focus on subjects where they naturally excel, to allow them to get a place at university. Most students in Russia as in other country study in the traditional way through programs designed for a wide range of individuals [2] and without taking into account individual characteristics [7]. Another problem is the precise meaning of the word 'like', which is difficult to determine between the ages of 7-18 and people often change their minds during the learning process [8]. A young person's choice of where to specialize should be facilitated by a systematic data analysis using information technology.

In addition, an important and interesting points in the management of education is the use of elements of competition among students, as well as the opportunity

\* Corresponding author: [annmakarova@muctr.ru](mailto:annmakarova@muctr.ru)

to participate in solving real problems in the area in which they have chosen.

Thus, the collection, processing and system analysis of information in a university in the modern world becomes the basis for the formation of individual student learning paths.

One of the important tasks in teaching students, including on individual trajectories, is to assess the effectiveness of their work in laboratories. This is especially true for students of chemical specialties. To carry out such a check, it is necessary to evaluate many different factors, and taking into account the fact that the perception of a number of facts can be subjective. To solve this problem, the authors of the article developed an original technique, which is presented below.

## 2 Methods

For the successful collection, system analysis and processing of large amounts of heterogeneous data, special tools were developed (including specialized indicators), algorithms (including the processing of statistical information in fields of nonparametric information to detect the presence of correlations between various factors) and databases.

An example of the use of such indicators is a system for testing the effectiveness of a student's work in the laboratory. It should be noted that a student's work in the laboratory is one of the most important elements of training of future specialists in fields of chemistry. The main system analysis tool is the visualization of testing the state of the laboratory and the level of students' interest in working in it.

The initial assessment of the state of the laboratory was carried out using a sociological survey of persons associated with the organization of the educational process in the laboratory. These are professors and teachers, top management of university and students. For this, a questionnaire was developed containing such sections as: "Documentation", "Room", "Personnel", "Equipment", "Laboratory glassware", "Workplace" and "Chemicals". And under each of the above items a list of questions was formed, each of which was evaluated on a four-point scale.

To assess the status of each put forward requirements presented in the questionnaire, items are assigned for each subparagraph of the section on a scale from 1 to 4, to determine the status of a particular indicator in the laboratory. The degree of compliance with the requirements includes the following levels of compliance:

- 1 (red zone) - requirements are not respected;
- 2 (orange zone) - insufficient compliance;
- 3 (yellow zone) - all important requirements are met;
- 4 (green zone) - requirements are being observed and improved.

Items are awarded in accordance with the above four-level scorecard. The result was evaluated by the formula:

$$Status = \sum score / Number\ of\ items\ in\ the\ section \quad (1)$$

Also, on a 4-point scale, the significance of each position was evaluated. Significance is assessed taking into account the importance and scores set for the section as a whole, and the influence of one item or another on the quality and safe conduct of laboratory work is taken into account. An example of several questionnaire items is presented in the Table 1.

**Table 1.** Questionnaire example.

№	Requirement	State				
		4	3	2	1	Comments
2	Documentation (significance = 2)					
...	...					..
2. 4	The laboratory should have job descriptions for each specialist.		3			Job descriptions are available and are located at the head of the laboratory.
...	...					..
5	Equipment (significance = 3)					
...	...					..
5. 6	Safety signs must be affixed to the equipment.			2		There are no signs, but each equipment is signed for safety.
...	...					..
8	Chemicals (significance = 3)					
...	...					..
8. 3	Reagents must be stored in specially equipped, well-ventilated, dry rooms.			2		A separate storage room for reagents is not provided.

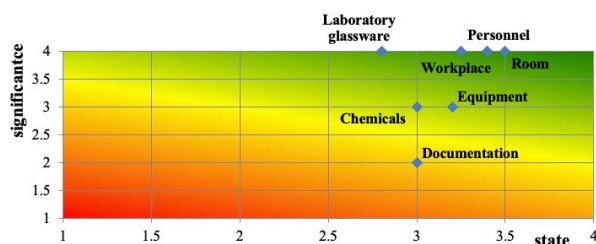
This questionnaire was posted on the Internet for the online survey. The results of self-diagnosis were collected separately in groups and analysed with using of visualisation tools.

## 3 Results and discussions

The test processing results are presented in the form of a state matrix (Fig.1). The matrix has a direction along two axes being "state" and "significance". The state matrix is a state assessment tool that involves some form of gradation of states. The state matrix shows a clearer view of what the state is, what is involved in it. On the state matrix, the green zone (upper right corner) is the zone where the state of the elements of the laboratory is considered satisfactory. The red zone (bottom left corner) is the zone where the state of the elements is not satisfactory and that may even pose a threat to the health of teachers and / or students. In addition, conducting experiments in such a laboratory can reduce students' interest in doing science.

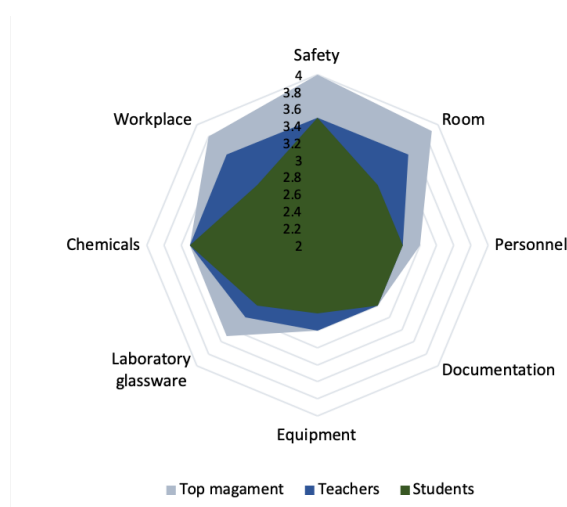
Figure 1 shows the state matrix that was obtained for one of the Russian universities. As can be seen from the matrix, the objects of research - documentation,

equipment, facilities and personnel meet the requirements of the standards, but can be improved. Objects - chemicals, workplace and utensils do not adequately meet the requirements. Corrective actions can be given to them to improve their condition and activities.



**Fig. 1.** Setting state matrix.

The evaluation results are also expressed in the form of a petal chart, in which the highest score of the indicator means the most compliance with the requirements presented in Figure 2.



**Fig. 2.** Petal chart for assessing the status of the laboratory by students, teachers and the top management of the institute.

It should be noted that an additional parameter "Safety" was introduced here. This parameter summarizes all the estimates obtained in various sections and allows you to assess the condition of the laboratory as a whole. Also, the "significance" of sections is not taken into account in this diagram. But this petal chart allow us to evaluate how different categories of respondents perceive the situation.

From the diagrams it can be seen that the assessment by the top management is different from the assessment of teachers and students. Differences in self-esteem may be due to the fact that interest and views on different areas are different. For example, students are more likely to experience workplace conditions than top management. The top management is inclined to idealize the situation and overestimate it a little. Students, on the other hand, tend to have very high expectations from the laboratory. This is especially evident in assessments of the condition of rooms and workplaces. Which may also be connected with a much better conditions of

laboratories in schools than in universities. This is due, among other things, to the fact that the laboratories in the school are more demonstrational objects, and serious research is being done in university laboratories and sometimes there is not enough time and energy to "gloss over".

## 4 Conclusion

Such visualization allows a better understanding of students' expectations and their dissatisfaction with the state of the laboratory. Using information resources, such testing can be widely carried out, and the results can be analysed over many years. Getting the dynamics of the weathering situation. As the experience of several universities has shown, after reading the test results, the situation improves, and the ratings of different groups become more similar. It is also obvious that this technology can be used not only to check the status of laboratories, it can be successfully applied to other elements of education at universities, such as lectures, seminars, classrooms and much more.

Also, one of the results of a systematic analysis of data in education is decision-making during the formation of an individual student learning path. The formation of such paths is a particularly effective tool in the preparation of narrowly oriented chemists, researchers and / or technologists, and their specialization in certain fields. And one of the areas where such training can be especially effective is the training of specialists in the field of corrosion. This need is because this area of chemistry requires certain skills and is developing very intensively.

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