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Measuring improvements of the education system in the COVID-19 pandemic – A case study of Serbia

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Abstract

The purpose of this paper is the comparative analysis of traditional education and e-learning by the application of key performance indicators. The general objective of the study is to indicate the advantages and disadvantages of traditional education and e-learning through the analysis and comparison of these two forms of education by applying defined key performance indicators. The research was carried out in 15 gymnasiums and vocational high schools in the Republic of Serbia, with a sample of 11.204 students (the school year 2018–19) and 11.251 students (the school year 2019–20). The results of the research and conducted comparative analysis presented in this paper indicate that e-learning during the COVID-19 pandemic has significant advantages over traditional education, such as a reduction in the percentage of students who were sent to the make-up exam and who did not complete the school year, a reduction of the number of imposed disciplinary measures and absences from classes per student at the end of the school year and an increasing percentage of excellent students at the school level at the end of the school year. Based on the results, recommendations for improving the education process by implementing e-learning in developing countries are proposed. This paper presents a valuable resource for educators and scholars in defining the elements that can improve student learning outcomes, motivation and satisfaction levels.

Keywords

Education, high school, COVID-19 pandemic, key performance indicators, Republic of Serbia

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Introduction

Scientific and technological achievements in recent years have significantly affected life, business and education. The application of modern technologies has led to changes in the most important objectives of further development of the educational process and its implementation. The development of information and communication technologies (ICTs) and their application in all spheres of business, as well as the visible disadvantages of traditional education, have led to the more intensive application of these technologies in education. Timely communication between

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teachers and students is needed for a successful educational process. By using modern ICTs and the Internet, this communication becomes more intensive, efficient and performed in real-time. Networking and multimedia are desirable in the education field (Agarwal and Pandey, 2013).

Education systems around the world have significantly reformed and changed, improving the school education quality (Rowe and Lievesley, 2002). Authors Liu et al. (2022) consider education as a mirror of society, while authors Kordigel Aberšek and Aberšek (2022) consider that education presents a social foundation that has to be conservative but to be future-oriented to create jobs and enable a student to work after graduation, using relevant technology. E-learning uses modern technology to enable access and upload of all needed educational resources to deliver education (Blezu, 2008). It highly affects teachers' to improve themselves professionally (Yildirim et al., 2022).

In early 2020, the world encountered with extremely unexpected coronavirus pandemic caused by the virus COVID-19. This pandemic developed a crisis in planning and management in the fields of learning, teaching and research (Menon and Motala, 2021) and exposed current inequality in different societies and education systems (Christie, 2021). After a few weeks of total lockdown, in the economy, everyday life and education, the only way to continue with the seemingly normal form of doing business and education were possible exclusively by applying modern ICTs. In education, e-learning has become the only possible form of education with respecting all epidemiological measures. During the COVID-19 pandemic, the Internet was a tool for information seeking, entertainment, education, communication and others (Nakayama et al., 2021). Teachers and students were required to switch to emergency remote education during that period (Knežević et al., 2022) with the main purpose of minimization of the spatial distance to ensure the persistence of education (Küçük-Avci et al., 2022), while all teaching and learning activities were changed from face-to-face instructions to fully online (Udeogalanya, 2022). One of the changes that the pandemic made in vocational education was the prevention of face-to-face meetings (Albrecht et al., 2021). Author Triyono (2015) considers that teaching a subject in vocational high school requires a specific strategy where these schools use computer base in instruction to deliver theory and practice subjects and to help teachers to make media a part of instruction. The main problem that arises is the transition from traditional education to e-learning in a short period of time.

In the developed countries where e-learning was already widely implemented, there were not too many challenges to continuing education in these extraordinary circumstances. But, in the Republic of Serbia, as in most developing countries, until the emergence of the coronavirus pandemic, the application of modern ICTs in education was in the early stages of development. In the second half of the school year 2019–20, the pandemic and lockdown forced the education system of the Republic of Serbia to quickly replace the traditional form of education. It is required to start with the application of e-learning at all levels of education throughout the country. For a comparative analysis of traditional education and e-learning in the Republic of Serbia during the coronavirus pandemic, this paper presents the possibility of applying key performance indicators as the tool for the comparison of these two forms of education. Based on the results, the advantages and disadvantages of these two forms of education, as well as recommendations for improving the educational process are pointed out. The problem of this research is to define a set of adequate key performance indicators (KPIs) as a tool for measuring the improvement of the educational system at different levels, the level of subjects, classes, schools or countries that have been achieved through the application of e-learning. This paper presents their application at the country level. The aim of this research is to determine if the application of e-learning creates better results than traditional education, i.e., does the application of technologies and distance learning affects the improvement of students' success? Based on that, the main hypothesis of this research is: "The application of e-learning improves student success compared to traditional learning". The research question defined from the aim of the research is: Whether student achievement and success have been improved using e-learning? The sample for this research was formed by selecting a certain representative number of gymnasiums and vocational high schools in the Republic of Serbia, as the two forms of secondary schools. The schools were selected according to the selection criteria of those that are the largest from the largest cities in the country, with the largest number of students, to collect a large amount of data for analysis and to show the real results at the level of the entire country.

In the laws on the basics of the education system and upbringing and secondary education and upbringing of the Republic of Serbia, it is stated that schools are obliged to supervise the improvement of education and upbringing and to determine the achievements and learning outcomes of students. Although the list of indicators and the method of their calculation for this purpose are not defined, prescribed and standardized, they are defined arbitrarily by school administrations. It results with analysis of student achievement results on the Teachers' Council are conducted based on a list of a large number of different indicators. The approach of measuring and analyzing a large number of indicators is inefficient, time- and resource-intensive, and contrary to the recommendations of leading authors in the field (Lee et al., 2019). Parmenter (2020) emphasizes that it is important to choose an adequate set of KPIs that are most valid for empirical research, rather than using a large number of KPIs. Nine adequate KPIs presented in the paper were selected from that list of a large number of different indicators, and the method of calculating them was defined by the author of the paper, with the aim of their standardization. These KPIs show the values of the most important performances of students in the education process, according to the most important criteria (Henriques and Marcenaro-Gutierrez, 2021). Also, they are the most suitable for the analysis of the education system's performances at the country level, as well as for the comparative analysis of the performances of traditional education and e-learning, which is presented in the continuation of the paper. By comparing the performances of traditional education and e-learning can be observed which method of education achieves greater effectiveness and efficiency among students, implies better student achievement, indicates a higher level of class participation, as well as better course exam scores and total outcomes. Based on the results, it can be concluded which type of education is better for improving student's performance and motivation to learn.

Traditional education vs. E-learning

Conventional teaching i.e., traditional education is teacher-centered (Somayeh et al., 2016). In secondary school the teacher's role is important because it affects reading competencies, competencies of written expression and expression in general as an assumption of (successful) communication (Pavičić Vukičević et al., 2022). Teacher-student interaction is of great importance to achieve learning outcomes: orientation is more on practical tasks, demonstrations, technical assistance and monitoring the activity performance with feedback as interaction (Chirikure, 2021). However, traditional education and its quality cannot satisfy the requirements of modern society, which requires individuals to independently collect, analyze and use the information and apply the gained knowledge in practice.

Traditional education is considered a new concept of teaching and learning, conducted using electronic technologies and media and has its origins in distance learning to increase the effectiveness of learning and thus teaching (Tularam, 2018). A distance learning environment uses a specific distance learning platform where lectures guide students to construct knowledge with feedback about their learning progress (Prasetyawan and Krismayani, 2021). The lecturers have a vital role in maintaining the motivation of already motivated students and intensifying the motivation of those who may not initially be inclined to participate in online learning (Baber, 2021). Many radical changes in learning have been made by the fast growth of information and communication technologies, creating e-learning (Baig et al., 2022). In e-learning, the teacher and the student are spatially distant from each other. By applying modern ICTs and with a good selection of teaching methods, e-learning improves the teaching process with the faster and more comprehensive acquisition of new knowledge. Students are independent and autonomous in planning and organizing learning, searching for solutions and removing obstacles. Today, the application of the Internet, ICTs, smartphones and computers greatly affect the learning and teaching processes (Idhalama et al., 2021). To gain good and broad education through e-learning, it is necessary to use digital textbooks and manuals, audio and video recordings, as well as numerous ICT devices. Also, to ensure the effectiveness and quality of e-learning, the course content must be reevaluated and adapted to be more suitable for online interaction, recognizing that the traditional content and syllabi may not seamlessly align with this learning environment (Baber, 2023). Two forms of resources are required to develop e-learning (Moreno-Guerrero et al., 2020): digital (teaching platforms, educational videos, podcasts, social networks, videoconferences, etc.) and technological (smartphone, tablet, desktop computer, etc.).

The main advantages of e-learning are (Baber, 2020; Castro and Tumibay, 2021; Harandi, 2015; Jiang and Jiang, 2021; Liebowitz and Frank, 2016; Mayer, 2017; Shahriar et al., 2021; Tularam, 2018): efficiency and productivity improvements, ease of access, personalized instruction and 24/7 help to students, additional online materials, using multimedia as video, animation or static, lower costs, increased attendance, fits a variety of learning styles, faster learning and facilitation of self-paced learning, joint activities and projects and various interaction types and simultaneous training of several teachers.

The main disadvantages of e-learning are (Artino and Jones, 2012; Cho and Cho, 2014; Dabbagh and Kitsantas, 2012; Sawang et al., 2013; Shahriar et al., 2021; Triyono, 2015): problems with an Internet connection, need for adequate equipment, insufficient teacher training, possession of a certain level of digital competencies in students, loss of concentration and higher dropout rates than students in conventional face-to-face classrooms, lack of social interaction and support from others, high development and implementation expenses, lack of discipline and conventional learning methods and negative impact on health, absence of emotions, facial expressions and body language.

In the paper Rohayani (2015) authors have presented a meta-analysis of the literature review defining research papers related to e-learning readiness. They have examined seven research papers that met the criteria and defined factors for the measurement of the readiness of e-learning. Some of them are technology, human resources, motivation, competence, culture and knowledge. Author Dorobat (2014) proposed a model for the evaluation of an E-Learning System Success (ELSS), based on four perspectives: social factors and benefits of using the e-learning system overall system quality, user perceived control, user attitude, usefulness and user satisfaction. Authors Hassanzadeh et al. (2012) have defined a set of indicators incorporated into the MELSS model for measuring e-learning systems success. Authors Wang et al. (2007) defined a multi-dimensional model for assessing e-learning systems success (ELSS) from the e-learner perspective by generating items, data collection and validation of a multiple-item scale for model measurement. Authors Davis and Wong (2007) have used CECIL, "the Web-based, online enterprise Learning Management System used to support academics and their students by means of a highly flexible and reliable system for information and communication".

In literature, different methods of comparing e-learning and traditional education are presented. Authors Khatri et al. (2013) conducted a survey to gather the opinions of both students and teachers and used a Donald L Kirkpatrick method to measure the effectiveness of training programs with five levels of evaluation. Authors in (Joksimović et al., 2015) have done a deep systematic computer-based literature search of papers issued on teaching and learning in online settings in many scientific databases, using search criteria "Title, abstract, and/or keywords must contain at least one of the following terms: meta-analysis, meta-synthesis, scoping study, OR systematic review" and "Title, abstract, and/or keywords must contain at least one of the following terms: distance learning, distance education, blended learning, blended education, hybrid education, hybrid learning, online learning, online education, e-learning, web-based learning, OR web-based education". Their results indicate a greater importance of e-learning compared to traditional face-to-face education. Also, for the better promotion of e-learning, they have proposed well-structured online discussions and courses with interactive content and adaptable deadlines, as well as personalized engagement of the teacher, providing timely and formative feedback. Bencheva (2010) made a comparison of traditional education and e-learning based on eight criteria: classroom discussions, learning process, subject matter, emphases in the learning process, motivation, teacher's role, location of learning and lesson structure. The main conclusion is that students have improved Internet skills and computer knowledge and they perceive distance learning platforms as more accessible and as better solutions for course participation. To conclude which type of education is better, Tucker (2001) has used the Canfield Learning Styles Inventory (CLSI) with 21 subscale variables grouped into four categories: "Conditions for Learning (Peer, Organization, Goal Setting, Competition, Instructor, Detail, Independence, Authority), Area of Interest (Numeric, Qualitative, Inanimate, People), Mode of Learning (Listening, Reading, Iconic, Direct Experience) and Expectation for Course Grade (A, B, C, D, and Total Expectation)". The results show that the knowledge gained by distance education is as good as traditional education.

The main reason that led to the reform of the educational system is the need to assess and monitor student learning outcomes, as indicators of meeting the objectives of this system. Identification of

performances considers the identification of performance indicators, measurement methods, benchmarks for results comparison and the reliability and the source of data used (Rajković et al., 2020). Performance measurement presents continuous monitoring and reporting on the achievements of the observed process where the result is a performance indicator (Samardžija et al., 2022). Author Parmenter (2020) states that KPIs focus on the most important aspects of organizational performance relevant to the current and future success of the organization. KPIs provide information that is important for decision-making and reduce uncertainty or risk (Kerzner, 2017) and have to be precisely specified and defined.

Managing large and complex systems, such as an education system, requires tools to measure the performance of that system. KPIs are used to monitor, improve and manage complex systems (Fitz-Gibbon, 1990). In educational institutions, it is important to precisely define KPIs, to obtain complete information about the quality or efficiency of education, which has often been the case in the past. Measuring the quality of education is of particular importance, especially when schools worldwide are reforming. Although basic KPIs of educational systems are measurements of student learning outcomes, many others are the basis for information, planning and decision-making.

A large number of indicators have been developed to measure education performance. Some of the most important indicators of student engagement in face-to-face learning environments are interaction, learning effort and passion, sense of belonging, participation in class activities, learning satisfaction and cognitive task-solving (Lee et al., 2019). Authors Wu and Chen (2012) suggest a preliminary framework of KPIs for education: educational background, educational resources, student activity, curricula and teaching, leadership and management, professional development, parental involvement and support, student learning performance, teacher teaching, and overall school performance. Schools differ in defining performance indicators. It is important to define a set of KPIs to monitor education quality in observed schools. KPIs can be used for measuring the accuracy of performance evaluation of scientific and teaching staff.

In addition to the problems in determining the effectiveness of education, as well as reaching a consensus on relevant performance that needs to be measured and monitored, it is necessary to determine a tool for measuring the quality of education and its improvement. Decisions are made based on information, which is why useful, reliable and timely information on the observed indicators' values is needed. Therefore, KPIs are defined as a tool for measuring the functional quality of an institution or an education system. Education indicators reflect important aspects of the education system and present statistics that report the condition of particularly significant features of the education system (Shavelson et al., 1990).

Methodology

In this paper, a set of nine KPIs is defined as a tool for comparative analysis of traditional education and e-learning in the Republic of Serbia. Then, based on the values of defined KPIs, a comparative analysis is conducted. The KPIs names and formulas for the calculation of the nine KPIs defined in this paper are presented in Table 1. These KPIs are analyzed at gymnasiums and vocational high schools in the Republic of Serbia at the sessions of the Teachers' Council, where the results of students and teachers are monitored and analyzed. The criteria for selecting a set of nine KPIs is that KPIs: must be simple and relevant, comprehensive within the observed type of education and important for the achievement of education goals; they need to be cost-effective, ensuring that data collection and in-depth analysis do not create excessive expenses; they should be statistical important and informative, to easily follow level of development of education; they should be based on valid, available and measurable data, enabling comparison with other school years; they should be consistent and reliable, creating a foundation for conclusions and decisions making (de Waal and Kourtit, 2013; Hollander, 2002; Luneva, 2015; Mullin and Kotval, 2003). A detailed analysis of student success, attendance, motivation and activities of each student is performed, to improve student success, as also the results of business success at the school level that is calculated semi-annually and annually. KPIs presented in Table 1. are explained in the following:

- *KPI 1. The number of absences from classes per student at the end of the semester/school year-APS:* is the quotient of the total number of student absences during the school year and the total number of students at the school level. The indicator is expressed in numbers and shows the average number of absences

Table 1. KPIs for comparative analysis of traditional education and e-learning in gymnasiums and vocational high schools in the Republic of Serbia.

No	KPI names	KPI formulas	The aimed value
1	KPI *APS*	$APS = \frac{\sum_{i=1}^{TNS} ASi}{TNS}$ [1] Where: • *APS*-Number of absences per student at the end of the semester/school year at the school level [1]; • *ASi*-Number of absences of each student at the end of the semester/school year [1]; • *TNS*-Total number of students at the school level at the end of the semester/ school year [1]; • *i*-Student, $i = 1,\ldots, TNS$.	as low as possible, i.e., ≈ 0 [1]
2	KPI *AG*	$AG = \frac{\sum_{i=1}^{TNS} AGSi}{TNS}$ [1] Where: • *AG*-Average grade of students at the end of the semester/school year at the school level [1]; • AGS_i-Average grade of each student at the end of the semester/school year [1]; • *TNS*-Total number of students at the school level at the end of the semester/ school year [1]; • *i*-Student, $i = 1,\ldots, TNS$.	as high as possible, i.e., ≈ 5 [1]
3	KPI *PES*	$PES = \frac{TNS-TNSER}{TNS} \cdot 100$ [%] Where: • *PES*-Percentage of excellent students at the end of the semester/ school year at the school level [%]; • *TNS*-Total number of students at the school level at the end of the semester/ school year [1]; • *TNSER*-Total number of students at the end of the semester/school year who did not have excellent results, i.e., number of students whose average grade is less than 4.50 [1].	as high as possible, i.e., ≈ 100 [%]
4	KPI *IDM*	$IDM = \frac{\sum_{q=1}^{Q} TIDMCq}{TNS}$ [1] Where: • *IDM*-Number of imposed disciplinary measures per student at the end of the semester/school year at the school level [1]; • *TIDMCq*-Total number of imposed disciplinary measures of each class at the end of the semester/school year [1]; • *TNS*-Total number of students at the school level at the end of the semester/ school year [1]; • *q*-Class, $q = 1,\ldots, Q$.	as low as possible, i.e., ≈ 0 [1]
5	KPI *AGG*	$AGG = \frac{\sum_{j=1}^{TNG} AGGGj}{TNG}$ [1] Where: • *AGG*-Average grade on the graduation exam of all high school graduates at the school level [1]; • $AGGG_j$-Average grade of each high school graduate on the high school graduation exam [1];	as high as possible, i.e., ≈ 5 [1]

(continued)

Table 1. (continued)

No	KPI names	KPI formulas	The aimed value
		• *TNG*-Total number of high school graduates (fourth-grade students) at the school level [1]; • *j*-Graduates, $j = 1,\ldots, TNG$.	
6	KPI *PJT*	$PJT = \frac{\sum_{q=1}^{Q} NSJTq}{TNS} \cdot 100[\%]$ Where: • *PJT*-Percentage of students that finished the school year in the first term (June term) at the school level [%]; • *NSJTq*-Number of students in each class who completed the class in the first term (June term) [1]; • *TNS*-Total number of students at the school level [1]; • *q*-Class, $q = 1,\ldots, Q$.	as high as possible, i.e., $\approx$ 100 [%]
7	KPI *PME*	$PME = \frac{\sum_{q=1}^{Q} NSMEq}{TNS} \cdot 100[\%]$ Where: • *PME*-Percentage of students sent to a make-up exam at the school level [%]; • *NSMEq*-Number of students in each class sent to the make-up exam [1]; • *TNS*-Total number of students at the school level [1]; • *q*-Class, $q = 1,\ldots, Q$.	as low as possible, i.e., $\approx$ 0 [%]
8	KPI *PAT*	$PAT = \frac{\sum_{q=1}^{Q} NSPMEq}{TNSAT} \cdot 100[\%]$ Where: • *PAT*-Percentage of students that finished the school year in the second term (August term) at the school level [%]; • *NSPMEq*-Number of students in each class who passed the make-up exam in the second term (August term) [1]; • *TNSAT*-Total number of students sent to the make-up exam in the second term (August term) at the school level [1]; • *q*-Class, $q = 1,\ldots, Q$.	as high as possible, i.e., $\approx$ 100 [%]
9	KPI *PNC*	$PNC = \frac{\sum_{q=1}^{Q} NSCNCq}{TNS} \cdot 100[\%]$ Where: • *PNC*-Percentage of students that did not complete the school year at the school level [%]; • *NSCNCq*-Number of students in each class who did not complete the school year [1]; • *TNS*-Total number of students at the school level [1]; • *q*-Class, $q = 1,\ldots, Q$.	as low as possible, i.e., $\approx$ 0 [%]

per student at the end of the semester/school year. It is measured on a semi-annual and annual basis (Table 1., Row No. 1);

- *KPI 2. An average grade of students at the school level at the end of the semester/school year-AG:* is the quotient of the sum of the average grades of all students at the school level and the total number of students. This indicator is expressed in numbers and shows the average grade of all students at the school level at the end of the semester/school year. It is measured on a semi-annual and annual basis (Table 1., Row No. 2);
- *KPI 3. Percentage of excellent students at the end of the semester/school year (at the school level)-PES:* is the quotient of the total number

of excellent students and the total number of students. The total number of excellent students is calculated as the difference between the total number of students and the total number of students with an average grade of less than 4.50. The indicator is expressed as a percentage and shows the percentage of excellent students at the end of the semester/school year at the school level. It is measured on a semi-annual and annual basis (Table 1., Row No. 3);

- *KPI 4. The number of imposed disciplinary measures per student at the end of the semester/school year-IDM:* is the quotient of the total number of imposed disciplinary measures during the school year and the total number of students at the school level. The number of imposed disciplinary measures is considered as the total sum of imposed measures in each class of the school. The imposed measures include a reprimand of the head teacher, a reprimand of the class council, a reprimand of the school principal and a reprimand of the Teachers' Council. This indicator is expressed in numbers and shows the average number of imposed disciplinary measures per student at the end of the semester/school year. It is measured on a semi-annual and annual basis (Table 1., Row No. 4);
- *KPI 5. An average grade on the graduation exam per student (at the school level)-AGG:* is the quotient of the sum of the average grades of all high school graduates (fourth-grade students) at the graduation exam and the total number of high school graduates. The indicator is expressed by a number and shows the average grade on the graduation exam at the school level. It is measured annually. The graduation exam is taken in three subjects in the following way: by writing composition from the subject of Serbian language and literature, as well as by taking two elective subjects. One elective subject is taken orally, while the other elective subject is taken by writing a final paper on a defined topic (Table 1., Row No. 5);
- *KPI 6. Percentage of students that finished the school year in the first term (June term) (at the school level)-PJT:* is the quotient of the sum of the number of students that finished the class in the first term (June term) and the total number of students in the school. The indicator shows the percentage of students that finished the school year on time, i.e., in the first, June term. It is expressed as a percentage and is measured annually (Table 1., Row No. 6);
- *KPI 7. Percentage of students sent to a make-up exam (at the school level)-PME:* is the quotient of the total number of students sent to the make-up exam and the total number of students at the school level. The indicator shows the percentage of students that were sent to the make-up exam and is measured annually (Table 1., Row No. 7);
- *KPI 8. Percentage of students that finished the school year in the second term (August term) (at the school level)-PAT:* is the quotient of the number of students that passed the make-up exam in the August term and the total number of students who were sent to the make-up exam. The indicator shows the percentage of students who finished the school year in August. It is expressed as a percentage and is measured annually (Table 1., Row No. 8);
- *KPI 9. Percentage of students that did not complete the school year (at the school level)-PNC:* is the quotient of the number of students that did not complete the school year and the total number of students at the school level. The indicator shows the percentage of students that did not complete the school year. It is expressed as a percentage and is measured annually (Table 1., Row No. 9).

The research in this paper was conducted on a sample of 15 gymnasiums and vocational high schools in the Republic of Serbia, out of a total of 515 sary schools at the end of the school year 2018–19 in the Republic of Serbia (Statistical Office of the Republic of Serbia, 2020). This number includes all secondary schools, including gymnasiums and vocational schools. The size of the analyzed sample is 11.204 students (the school year 2018–19 – traditional education) and 11.251 students (the school year 2019–20 - e-learning during the coronavirus pandemic). For Electrical Engineering High School "Stari Grad" (school 1), Technical School Čačak (school 2), Gymnasium Čačak (school 3), High School of Economics Čačak (school 4), and Electrical Engineering High School "Zemun" (school 7) are used internal data from schools (Electrical Engineering High School "Stari Grad"-Beograd, 2019, 2020; Electrical Engineering High School "Zemun", 2019, 2020; Gymnasium Čačak, 2019,

Table 2. Values of KPIs for gymnasiums and vocational high schools in the Republic of Serbia for the school year 2018–19 – traditional education.

TRADITIONAL EDUCATION									
School No	*APS [1]*	*AG [1]*	*PES [%]*	*IDM [1]*	*AGG [1]*	*PJT [%]*	*PME [%]*	*PAT [%]*	*PNC [%]*
1	170.06	3.37	10.58	0.15	4.16	95.51	4.33	100.00	0.16
2	65.34	3.86	31.06	0.08	4.36	87.83	11.06	88.76	2.36
3	65.57	4.31	51.99	0.01	4.65	99.91	0.00	0.00	0.09
4	85.59	3.96	26.15	0.04	4.08	96.54	3.33	96.15	0.13
5	108.11	3.51	9.00	0.17	2.89	87.08	12.33	95.24	1.57
6	108.24	3.64	26.61	0.14	3.97	96.86	0.30	100.00	2.84
7	136.85	3.66	18.82	0.25	4.20	87.07	10.37	71.60	2.56
8	111.76	4.06	34.12	0.13	4.47	99.41	0.59	100.00	0.00
9	54.35	4.04	38.65	0.10	4.38	100.00	0.00	0.00	0.00
10	103.94	3.95	32.49	0.20	4.24	96.07	4.19	57.58	1.78
11	125.30	3.24	19.62	0.31	3.73	85.51	7.56	77.97	3.46
12	84.29	4.49	60.00	0.00	4.88	99.78	0.22	100.00	0.00
13	157.95	3.53	19.55	0.19	4.21	98.57	6.92	96.97	1.22
14	95.69	3.74	14.19	0.02	3.67	94.88	4.88	100.00	0.00
15	87.83	3.44	15.00	0.29	3.75	96.19	1.86	100.00	1.94
Average	102.69	3.77	26.46	0.15	4.11	94.32	4.71	87.10	1.33

2020; High School of Economics Čačak, 2019, 2020; Technical School Čačak, 2019, 2020).

For Food and Catering School Čačak (school 5), Technical School Zaječar (school 6), The First Economic School-Beograd (school 8), Gymnasium of Prijepolje (school 9), High School of Economy Trade "Jovan Trajković"-Zrenjanin (school 10), Technical School Obrenovac (school 11), Gymnasium "Sveti Sava" Požega (school 12), Food Processing and Chemistry School Niš (school 13), Secondary Technical School "Mihajlo Pupin"-Kula (school 14), and Technical School "Ivan Sarić" Subotica (school 15) the data was accessed via schools Internet sites (Food and Catering School Čačak, 2019, 2020; Food Processing and Chemistry School Niš, 2019, 2020; Gymnasium of Prijepolje, 2019, 2020; Gymnasium "Sveti Sava" Požega, 2019, 2020; High School of Economy Trade "Jovan Trajković"-Zrenjanin, 2019, 2020; Secondary Technical School "Mihajlo Pupin"-Kula, 2019, 2020; Technical School Zaječar, 2019, 2020; The First Economic School-Beograd, 2019, 2020; Technical School Obrenovac, 2019, 2020; Technical School "Ivan Sarić" Subotica, 2019, 2020). Data used in the analysis are from the end of school years 2018–19 and 2019–20.

Results

Table 2 shows the values of nine KPIs defined in the previous section for all 15 gymnasiums and vocational high schools for traditional education. These data are from the school year 2018–19, when classes were held in classrooms in schools, in the traditional way.

Table 3 shows the values of all KPIs defined in the previous section for all 15 gymnasiums and vocational high schools for e-learning. These data are from the school year 2019–20 when classes were held mostly online.

A graphical presentation of the comparative analysis of traditional education and e-learning is shown in Figure 1.

Table 4 shows the calculated average values of nine KPIs for all 15 gymnasiums and vocational high schools for traditional education and e-learning. Not all observed KPIs are expressed in the same units. However, to calculate the difference between traditional education and e-learning, the calculation formula presented in equation (Eq. 1) is used. The results are presented in a column *Difference in [%]*.

$$D = \frac{EL}{TE} \cdot 100 - 100[\%] \tag{1}$$

Where:

- *D*-Difference in values of e-learning and traditional education [%];
- *EL*-Value for e-learning (unit of measure varies from KPI, can be [1] or [%]);
- *TE*-Value for traditional education (unit of measure varies from KPI, can be [1] or [%]).

Table 3. Values of KPIs for gymnasiums and vocational high schools in the Republic of Serbia for the school year 2019–20 – e-learning.

E-LEARNING									
School No	*APS [1]*	*AG [1]*	*PES [%]*	*IDM [1]*	*AGG [1]*	*PJT [%]*	*PME [%]*	*PAT [%]*	*PNC [%]*
1	108.21	3.47	12.08	0.05	4.38	99.68	0.32	100.00	0.00
2	43.67	4.02	34.49	0.02	4.61	98.26	1.39	50.00	1.04
3	41.26	4.63	60.04	0.00	4.88	100.00	0.00	0.00	0.00
4	61.75	4.23	28.89	0.05	4.16	99.22	0.78	100.00	0.00
5	71.89	3.77	15.15	0.09	4.43	98.72	0.64	100.00	0.27
6	85.68	3.62	25.62	0.07	4.36	98.15	0.00	0.00	1.85
7	88.60	3.77	20.54	0.33	4.35	97.89	0.59	100.00	1.53
8	69.65	4.18	39.15	0.05	4.53	99.88	0.12	100.00	0.00
9	36.73	4.21	45.06	0.05	4.33	100.00	0.00	0.00	0.00
10	90.13	4.02	33.69	0.22	4.35	99.47	0.53	100.00	0.00
11	73.44	3.16	24.63	0.03	4.12	94.41	2.93	100.00	2.53
12	56.99	4.58	71.79	0.00	4.88	100.00	0.00	0.00	0.00
13	110.78	3.73	24.17	0.17	4.00	98.00	1.33	100.00	0.67
14	69.12	3.78	17.15	0.01	3.94	98.66	1.34	100.00	0.00
15	67.39	3.57	16.77	0.07	3.83	98.97	0.87	100.00	0.16
Average	70.50	3.91	30.26	0.08	4.36	98.74	0.73	92.68	0.54

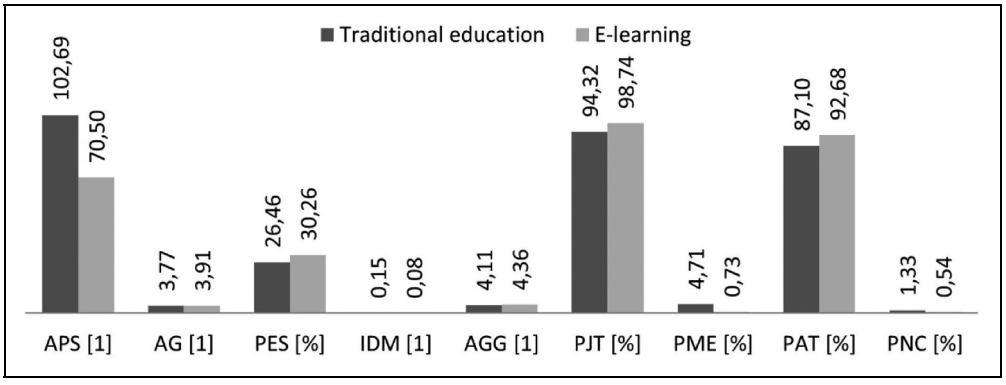

Figure 1. Graphic presentation of the results of the comparative analysis of traditional education and e-learning in gymnasiums and vocational high schools in the Republic of Serbia by application of KPIs.

Table 4. Results of comparative analysis of traditional education and e-learning in gymnasiums and vocational high schools in the Republic of Serbia by application of KPIs.

No.	KPI	Traditional Education	E-learning	Difference in [%]	Rank
1	*APS* [1]	102.69	70.50	−31.35	4
2	*AG* [1]	3.77	3.91	3.71	9
3	*PES* [%]	26.46	30.26	14.36	5
4	*IDM* [1]	0.15	0.08	−46.67	3
5	*AGG* [1]	4.11	4.36	6.08	7
6	*PJT* [%]	94.32	98.74	4.69	8
7	*PME* [%]	4.71	0.73	−84.50	1
8	*PAT* [%]	87.10	92.68	6.41	6
9	*PNC* [%]	1.33	0.54	−59.40	2

Data analysis

In Table 4, in the Rank column, the values of the differences between e-learning and traditional education are ranked according to the observed KPIs. Rank 1 presents the highest difference in value and rank 9 presents the lowest difference in value. Based on the results shown in Table 4, it can be concluded that there are significant differences in the values of the KPIs for traditional education and e-learning. The highest negative difference between traditional education and e-learning, supporting e-learning, was noted in KPI PME (rank 1). It indicates that in e-learning, a significantly lower percentage of students (84.50 [%]) referred to the make-up exam than in traditional education. This is also the largest difference between e-learning and traditional education observed within KPIs. The largest positive difference between traditional education and e-learning, that also promoted e-learning, was noted in the KPI PES (rank 5). This value indicates that e-learning had a higher percentage of excellent students at the end of the school year, even 14.36 [%] more than traditional education. The lowest difference between e-learning and traditional education was noted in KPI AG (rank 9) and indicates that the average grade of students at the school level at the end of the school year did not change significantly with the change in teaching methods. It increased by switching to e-learning for only 3.71 [%].

Based on the data presented in Table 4 and Figure 1, a detailed analysis of the results obtained for traditional education and e-learning, with additional explanations from the literature review follows. By applying e-learning, the number of absences from classes per student (KPI APS) at the end of the school year 2019–20 was 31.35 [%] less compared to the traditional education in the previous school year 2018–19. It averaged 70.50 absences per student, while in traditional education the number was much higher and averaged 102.69 absences per student.

The average grade of students at the school level (KPI AG) at the end of the same school year in e-learning increased slightly, by 3.71 [%]. It amounted to 3.91, while in traditional education it amounted to 3.77. The percentage of excellent students at the school level at the end of the same school year (KPI PES) in e-learning increased by 14.36 [%] and amounted to 30.26 [%], while in traditional education it amounted to 26.46 [%].

The number of imposed disciplinary measures per student at the end of the observed school year (KPI IDM) in e-learning is significantly lower by 46.67 [%] and amounts to an average of 0.08 disciplinary measures imposed per student, while in the traditional education, this number averaged 0.15.

The average grade on the graduation exam per student at the school level and the percentage of students that finished the school year in the first term (June term) have not much differed in e-learning. The average grade on the graduation exam per student at the school level (KPI AGG) is higher by only 6.08 [%] and amounts to an average of 4.36, while the percentage of students that finished the school year in the first term (KPI PJT) is higher by 4.69 [%] and amounts to 98.74 [%] in the observed school year. The significant difference is in the KPI PME, which refers to the percentage of students that were sent to the make-up exam. In e-learning, more students finished with positive grades in all subjects and there was a decrease in the percentage of students who had to take a make-up exam by 84.50 [%]. In e-learning, an average of 0.73 [%] students were referred to a make-up exam, while in traditional education it was 4.71 [%]. Significantly positive change was observed in the percentage of students that finished the school year in the second term (August term) (KPI PAT). By 6.41 [%] more students completed the year in the second term than with traditional education. Thus, in e-learning 92.68 [%] of students completed the school year in the second term, while in traditional education it was 87.10 [%].

Another significant difference was noted in the percentage of students that did not complete the school year (KPI PNC). In e-learning, only 0.54 [%] did not complete the school year, which is 59.40 [%] less compared to traditional education. In traditional education, the percentage was 1.33 [%].

Discussion

The decrease of the number of absences from classes per student (KPI APS) in e-learning was expected since all activities were carried out from home, as well as studying, working and worshiping at home (Putra and Radita, 2020) to slow down the spread of the coronavirus (Yulia, 2020). No physical contact was allowed, students were at home, using digital tools for listening and participating in classes. The research done by the authors Darling-Aduana et al. (2022) shows that students with a higher proportion of instructional days in online mode had higher attendance rates than students that were in face-to-face

mode. Also, according to the Law of Secondary Education in the Republic of Serbia (The Law of Secondary Education, 2023), the minimum that a student must attend is two-thirds of the scheduled number of classes per subject.

The increase of the average grade of students at the school level (KPI AG) and the percentage of excellent students at the school level at the end of the same school year (KPI PES) in e-learning was expected since materials were usually recorded and available online so that all students can follow (Udeogalanya, 2022). This was very helpful for them when they were sick or not able to participate in class, so they could keep up with all class materials and homework requests for the following classes.

The decrease of the number of imposed disciplinary measures per student at the end of the observed school year (KPI IDM) in e-learning was also expected since e-learning does not require physical contact between students and teachers, as well as staying in school.

The decrease in the percentage of students that did not complete the school year (KPI PNC) can be a result of implementing different tools and methods to satisfy students' needs (Wingo et al., 2016) for better presentations and explanations of teaching and learning materials, as well as more invested time for self-directed learning besides the time for attending online classes and for watching teaching and lecture recorded videos (Kim et al., 2022).

Conclusions and recommendations

The comparative analysis of traditional education and e-learning by applying KPIs, on the example of 15 gymnasiums and vocational high schools in the Republic of Serbia, was presented in this paper. Based on the results, the main hypothesis "The application of e-learning improves students' performances and motivation, compared to traditional learning" is confirmed and it can be concluded that e-learning has an advantage over traditional education in all the observed KPIs. A comparative analysis of these two different forms of education showed that significant differences were observed at the end of the school year supporting e-learning: a reduced percentage of students sent to make-up exams (84.50 [%]), a reduced percentage of students that did not complete the school year (59.40 [%]), as well as an increased percentage of excellent students (14.36 [%]). Increases were also observed in the percentage of students that finished the school year in the second term (August term - 6.41 [%]), the average grades on the graduation exam per student (6.08 [%]) and the percentage of students who finished the school year in the first term (June term - 4.69 [%]). These results are in accordance with the research results presented by Elshareif and Mohamed (2021) and Li and Tsai (2017) that confirmed that e-learning and the application of e-teaching materials contribute to students' motivation to learn and improve their performances. Also, the application of technology improves students' motivation (Irawan et al., 2019), while technology enables enhancement and extension of the learner process (Singh et al., 2005). The reduced number of imposed disciplinary measures per student (46.67 [%]) and reduced number of absences from classes per student (31.35 [%]) is consistent with that e-learning reduces face-to-face interaction and social contact between students and between students and teachers, as presented in (Al Rawashdeh et al., 2021; Stecuła and Wolniak, 2022). The minor difference between e-learning and traditional education was noted in the average grade of students at the school level at the end of the school year (3.71 [%]). The research results in (Asandului and Ceobanu, 2008) show that the greater half of surveyed students (66 [%]) prefer blended learning, i.e., both traditional education and e-learning. The same authors consider that these two types of education are not necessarily alternatives, but they should complement each other, and students can use e-learning to expand their educational experience.

Additionally, increases in results can be presented as a positive consequence of e-learning because during e-learning students have easier access to the teacher and available information access at any time (Abed, 2019), options for additional help from the teacher as well as an emphasis on the independent learning environment and supporting collaborative learning (Lee et al., 2019).

Some of the recommendations for improving the education system by implementing e-learning in developing countries are:

- *Reform of the education system.* In secondary education, it is necessary to define standards for learning outcomes, knowledge and skills with the application of modern ICTs, that the student should possess at the end of a school year;
- *Improving teachers' digital competencies.* By attending professional seminars in selected

areas of ICTs, the teachers will acquire digital competencies, and will be able to effectively apply digital tools and educational platforms during the teaching process;

- *Increased student activity and increased digital competencies.* It is necessary to encourage students to participate in classes as much as possible and increase their digital competencies by applying a wide range of possibilities of ICTs tools and platforms intended for education (tests, games, workshops, presentations, etc.), tailored to their age and knowledge;
- *Implementing best practices from developed countries.* Some examples of best practices are: the application of more platforms and software for teaching and learning, as well as software that provides to take tests and display the achieved points and grades after completing the exam; applying different knowledge of teachers in the field of ICTs to make the materials more interesting and easier to remember for students; recording lectures and holding online tests; tendency towards the development of virtual schools that can receive a much larger student population and classes that are location-independent; cooperation with companies to provide online practical classes whereby students gain practical knowledge and develop dual education; demonstration of practice in software or online access to certain software that students need for the job after graduation, etc.;
- *Creating adequate social awareness of the advantages of e-learning.* The advantages are numerous and reflected in the possibility of access to classes and teaching materials from different locations and at different times, when it suits the student, as a self-organized learning time;
- *Increasing financial investments in ICTs for e-learning, as well as the improvement of IT support.* This is important to enable faster implementations of e-learning, teaching materials, student and teachers' data security, etc.

This paper can help scholars, researchers and educators to better understand the difference between traditional education and e-learning and to direct them to choose appropriate education form for achieving better students' motivation, performances and remarks. The results of this paper will provide valuable insights for all stakeholders involved in the education system, whether they are transitioning to or have already adopted e-learning. Considering all the advantages, experiences and achieved results in the realization of e-learning in the educational process during the coronavirus pandemic, it can be expected that this form of education will be increasingly applied in educational practice in all countries around the world. One of the directions of future research of the authors of this paper is to apply a set of defined KPIs at the level of primary education in the Republic of Serbia for the same two school years, that could conduct a comparative analysis of results achieved at these two levels (primary and secondary) of education in the same observation period. Another direction of future research of the authors of this paper is to apply a set of defined KPIs to gymnasiums and vocational high schools in countries in the region, where the level of implementation of e-learning is similar. Based on that a comparative analysis of results could be conducted among countries in the region.

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Declaration of interests

The authors declare no competing interests.

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