Scientometrics (2020) 124:2319–2339
https://doi.org/10.1007/s11192-020-03554-x

Development of science and education in the Western Balkan countries: competitiveness with the EU

Živan Živković[1] · Marija Panić[1]

Received: 31 January 2020 / Published online: 13 June 2020

Abstract

The paper presents the results achieved in the development of education and science in the Western Balkans (WB) countries, through a comparative analysis of the PISA test results, the universities ranking on the ARWU list, and the citation of researchers (educating students in these countries) in particular fields of science. An analysis of the results achieved by scientific workers from the WB countries was also made, by the number of papers in journals on the SCIe, SSCI, A&HCI and SJR lists in the period 1996–2018, as well as the places of researchers in the citation of researchers from all over the world according to the Stanford model for the period 1996–2018. A development model for WB countries has been proposed, whereby they can acquire measurable competencies as a starting point for equal negotiations for their entry into the EU and gain a respectable position in the world.

Keywords Education · Science · Western Balkans · Competencies · EU

Introduction

The beginning of the 21st century brought important notes for the internationalization of growth and sustainable development, which provides a better life for people with their willingness to accept the changes that are needed (Avelar et al. 2019). The United Nations (UN) has set eight Millenium Development Goals (MDGs), which represent a sustainable development agenda, and at the same time a challenge for all nations to reach them under the 2030 Agenda adopted (UN 2018a). The adoption of the Agenda by 2030 (UN 2018b) listed the priorities and important changes in education because the development path relies on the development of education (Avelar et al. 2019). The education level of the national leaders of decision-making has a direct impact on the scope of the decisions taken in the continuous increase in sustainable development (Kolb et al. 2017; Zhou and Lu 2018; Hund et al. 2019; Li et al. 2019). It is indicated that visible progress should be made in the education system at all levels of education: primary, secondary (Milovantseva et al. 2018), and especially the university one, through internationalization and global student

✉ Marija Panić
mpanic@tfbor.bg.ac.rs

[1] Engineering Management Department, Technical Faculty in Bor, University of Belgrade, Vojske Jugoslavije 12, Bor, Serbia

mobility since 2020 (Avelar et al. 2019). Based on the bibliometric analysis of 193 papers in 2015–2018, the structure and knowledge base of education were identified to improve and implement MDGs and identified top institutions for advancement in the implementation of MDGs mainly located in the Western Hemisphere (Avelar et al. 2019).

As global competition forces organizations to maintain the high quality of their products in order to achieve customer satisfaction, there is a need for higher education institutions to ensure that their programs and projections enable students to become professionals with the skills and competencies required by the current global environment (Maciel-Monteon et al. 2020). The quality of the education system is thought to be crucial for economic development in the world (Ah-Teck and Starr 2013), and the quality of higher education is one of the major pillars of a country's development (Dlouhá et al. 2017). Developed countries have systematic activities in education, as the first development priority of the country, from which comes the development of science and technology, which has a direct impact on the development of economy and quality of life of citizens (Gaus 2008; Vilić 2014). Many countries are taking some action in this direction to increase their competences and reputation in the world (Lavalle and de Nicolas 2017). This is not the case for poorly developed countries identified as less developed countries (LDCs). In these countries, difficulties and problems are not trivial. They stem from the education system, which hinders the internationalization of research and development activities (Albuquerque 2016), which induces the creation of autocratic regimes that do not favor the development of education, which puts these countries in a state of developed corruption and poverty (Goldberg 1998; Albuquerque 2016). The development of science and education, especially in developing countries, increases the competencies of the majority of the population and has a positive effect on strengthening the overall human potential, which has a significant impact on the development of democracy and the reduction of corruption in these countries (Vilić 2014).

In order to make progress in developing countries, it is necessary for those countries to find areas where they are significantly better than their competitors. These may be a better-trained workforce, more favorable natural resources or scientific and technological opportunities, which should contribute to the adaptation of the country's development to local circumstances by strengthening education. Science and scientists can play an important role in determining these choices and implementing development strategies (Goldberg 1998; Maciel-Monteon et al. 2020). Researchers need to be included, as advisers, in bodies where strategic and operational decisions are made by the Government and the industrial sector, which undoubtedly contributes to the development of the country as a whole and enhances its competence and reputation in the world (Barabási et al. 2002). Developing countries often lack the desire of the ruling elites to work closely with academics from universities and scientific institutes. As a result, universities and research centers become isolated from the rest of the country. These centers are linked to research centers, primarily in the EU and the US, generating joint scientific results, so they are clearly not contributing to their own country's development in terms of developing new products and technologies that open new markets and enlarge existing ones (Beaver and Rosen 1979).

Western Balkans (WB) countries: Serbia, Bosnia and Herzegovina, Montenegro, Albania, Northern Macedonia and Kosovo* (*UN resolution 1244 has not defined status), belong to a group of developing countries operating in transitional economic conditions. These countries are seeking to become part of the EU. Only Serbia and Montenegro are in the stage of accession negotiations, and the other four countries have not yet taken the first step on the road to the EU. Science is a central driver for society and economic development since scientific knowledge and innovative ideas are not bound by any boundaries and are available to anyone who wants to consume them (Bak 2018; Maciel-Monteon et al.

2020). Also, science is a basic resource for the development of education at all levels and especially at the university level. The position of the scientific system in the EU and Southeast Europe is a strong signpost for WB countries as well. The EU constantly reiterates the recommendation that at least 3% of the GDP should be allocated for scientific research. The situation in the WB countries is such that, for the development of science, less than 1% of GDP is earmarked for higher education, with a decreasing trend (Dumciuviene 2015). These facts point to the incompatibility of the system functioning of those WB countries with the EU system. The basic hypothesis of this study is that the analysis of the level of science and education in WB countries takes into account the possibilities of updating education systems in WB with the attained level in these areas in the EU.

Framework for the area investigated

In recent times, the WB region has been increasingly attracting attention in the world, and in particular in the EU, in terms of the achieved level of standardization and compatibility for entry into the EU system. Reaching the level of functioning of international EU standards can also be seen through the development of science and education, as a starting point for the development of all other areas that make the quality of life in line with contemporary EU standards (Habibov and Cheung 2017). In order to look at the attained level in the field of education (all levels) and science in the WB, as the basic shell of potential for the development of each country, and therefore for the development of science and education, a comparison was made with the achieved level in the mentioned fields in the developed EU countries (Table 1), which are approximately the same in terms of population with WB countries (Dlouhá et al. 2017). Also, population growth in these countries is shown as an indicator of the level of development achieved (https://en.wikipedia.org/wiki/List_of_count

Table 1 Population and population growth rates in WB countries to compare educational and scientific potential

Rank in the total scientific score in the world (1996–2018)	Number by population in WB countries	Country	Population in the country (2018)	Population growth (%)
52	1	Serbia	8.7×10^6	−0.50
94	2	Bosnia i Herzegovina	3.3×10^6	−0.30
95	4	Northern Macedonia	2.1×10^6	+0.10
119	3	Albania	2.8×10^6	−0.10
–	5	Kosovo*	1.8×10^6	+0.80
124	6	Montenegro	0.63×10^6	+0.03
Comparison with countries similar in population				
16	Switzerland		8.4×10^6	+1.10
18	Sweden		10.2×10^6	+0.65
23	Denmark		5.6×10^6	+0.70
26	Finland		6.1×10^6	+0.30
30	Norway**		5.3×10^6	+0.90

*According to UN resolution 1244, the status has not yet been defined

**Norway is not a member of the EU, but has been taken into account for comparison purposes due to population ries_by_population_growth_rate. Accessed 10 December 2019). Table 1 in the first column also shows the result for the analyzed countries achieved in the scientific ranking of 239 countries from around the world for the period 1996–2018 according to a number of criteria of scientific competence (https://www.scimagojr.com/countryrank.php. Accessed 10 December 2019).

For the development of the state in all its segments, it is necessary to develop higher education with international quality of output, which is reflected in the knowledge and acquired skills to give adequate answers to the demands from the global environment (Avelar et al. 2019). In order to achieve this, the conditions of quality inputs to higher education are necessary, which are reflected in the quality of students' knowledge they bring from previous levels of education, the quality of teachers and the quality of advanced science in universities. For these reasons, this study will analyze the above inputs as a basis for quality highways expected of university education (Sulis et al. 2019; Avelar et al. 2019; Maciel-Monteon et al. 2020).

The results presented in Table 1 indicate that in the WB countries slight positive population growth is present in Montenegro, Northern Macedonia, and Kosovo*, while in other countries it is negative, which causes a continuous decrease in population. The massive departure of young people to the West (EU and US) further diminishes the potential of these countries. In comparison countries, population growth is positive and even higher several times than in Northern Macedonia and Montenegro (with positive growth), and approximately the same as in Kosovo*, indicating that WB countries are in serious demographic problems.

The quality level of education and science achieved in WB countries

Quality of primary education

In the modern world, the quality of education in the country is measured by the quality of the outputs of each level: primary, secondary and higher education. It is indisputable that the quality of primary education forms the basis for all subsequent levels of education. The quality of primary and secondary education is measured in the Organization for Economic Co-operation and Development (OECD) by organizing so-called PISA (Programs for International Student Assessment) testing. This testing has been conducted worldwide since 2000 every 3 years and involves testing 15-year-old students in the field of Mathematics, Science, and Reading. The number of countries participating in this testing is steadily increasing: 40 in 2000, 39 in 2003, 51 in 2006, 57 in 2009, 72 in 2015, and 79 in 2018 (Sulis et al. 2019), which indicates that the interest in measuring the competence of students in the world increases. About 600,000 15-year-olds from around the world participated in the last test, and about 8000 students in Serbia (Serbia is taking part in PISA testing for the first time). All ZB countries took part in this testing in 2018 and the results obtained are shown in Table 2 (https://en.wikipedia.org/wiki/Programme_for_International_Student_Assessment Accessed 10 December 2019).

PISA results are a reliable indicator of the quality of education in countries where testing is done, given that all the students tested in the same way. The results indicate the chances of future staff in international competition at the global level. Staff created in countries with low levels of knowledge of students, cannot be equal with colleagues from countries where quality education is implemented, due to the large difference in the level of

Table 2 PISA test results in 2018 (79 countries participated)

Overall rank	Country	Reading Average score of all participants: 489		Mathematics Average score of all participants: 489		Science Average score of all participants: 487	
		Rank	Points	Rank	Points	Rank	Points
45	Serbia	45	439	46	448	46	440
52	Montenegro	52	421	53	430	61	415
61	Bosnia and Herzegovina	62	403	62	406	67	398
62	Albania	61	405	48	437	59	417
67	Northern Macedonia	67	393	53	430	63	413
75	Kosovo*	75	353	75	366	75	365
Selected countries' position for comparison							
7	Finland	7	520	16	507	6	522
11	Sweden	11	506	17	502	19	499
18	Denmark	18	501	13	509	25	493
19	Norway	19	499	19	501	27	490
28	Switzerland	28	484	11	515	23	495
The highest ranked country in the world							
1	China**	1	555	1	591	1	590
The worst ranked countries in the world							
78	Philippines	79	340	78	353	78	357
79	Dominican Republic	78	342	79	325	79	336

*According to UN resolution 1244, the status has not yet been defined

**Only students in four regions of the Republic of China were tested

knowledge acquired, which will put these people in an inferior position in the future (Sulis et al. 2019).

The obtained results in Table 2 indicate the functional illiteracy of every third student in Serbia and one in two in Bosnia and Herzegovina, Montenegro, Northern Macedonia, and Albania. In Kosovo*, this share is higher. The results obtained in 2018 are worse than the results of these countries in previous PISA tests, indicating that the quality of education in WB countries is declining and that the quality of primary education is among the lowest in the world (Lu and Zhang 2019; Li et al. 2019). It is no coincidence that China occupies the best position in the PISA test, which is influenced by state policy that places the development of education at all levels in the first priority (Lu and Zhang 2019; Li et al. 2019). Particular attention is paid to the education of children in rural areas, so that everyone is given the same opportunities in education as a starting point for further career development (Lu and Zhang 2019).

Quality of university education

PISA results indicate an increasingly poor education quality input from lower education levels to university, in all WB countries. This fact necessarily leads to a decline in the quality of higher education outputs in these countries, which creates alarming problems that need to be addressed urgently (Ah-Teck and Starr 2013) by introducing international quality standards and The Baldrige Performance Excellence Program (BPEP) at all levels of study in WB countries (Maciel-Monteon et al. 2020). University education in each country is the basis for its development. The quality of university education, to a large extent, depends on the quality of knowledge of students who come to university. From students with poor initial knowledge from previous levels of schooling (Yau and Cheng 2013), it is not possible to create a quality staff with recognizable knowledge and skills in the process of university-level education (Lavalle and de Nicolas 2017).

In higher education, the infrastructure of the university and the scientific results of the professors form the basis for the quality of graduates' output, which means their ability to develop the innovation, technological development and economy of the country in which they work (Holm et al. 2015; Avelar et al. 2019). In WB countries, education has become a lucrative private business, where profits are provided through the number of students, and the quality of teaching is not a priority for owners and employees. Table 3 shows the higher education infrastructure through the number of universities and colleges (public and private) in the WB countries, as well as in the countries selected for comparison (*Sources*: WEB sites of accreditation bodies for higher education in the considered countries—Accessed 10 December 2019).

Universities in the world are not recognized for their beautiful buildings, beautiful lectures, number of students and diplomas, but by scientific discoveries, methods, patents and innovations (Gavine et al. 2019), that is, international publications and citations of published results (Ioannidis et al. 2016; Vilić 2014; Živković et al. 2017a, Fiala et al. 2017). Based on these results, universities in the world are ranked according to various lists (Jakobs 2010; Daraio et al. 2015), among which the most popular is Shanghai List or ARWU (Academic Ranking of World Universities), which covers the top 500 universities,

Table 3 Number of universities and colleges (public and private) in WB countries

Number	Country	Number of universities and academies		Number of colleges	
		State	Private	State	Private
1	Serbia	8 (97 faculties)	11 (109 faculties)	About 50 (Belgrade 14)	More than 100 (Belgrade 18)
2	Bosnia and Herzegovina	8 (104 faculties)	16 (91 faculties)	4	13
3	Montenegro	1	17	–	–
4	Albania	1	17	–	–
5	Northern Macedonia	5	15	–	–
6	Kosovo*	3	7	No data	
Selected countries' position for comparison:					
1	Switzerland	12 6 of applied sciences 2 federal technical 11 cantonal	–	–	–
2	Norway	10	–	34	–
3	Finland	10	–	5	–
4	Denmark	8	–	11	–
5	Sweden	3 Recommended for international students	–	–	–

Table 4 WB Universities ranked among the top 1000 in the Shanghai list for 2019

Number	Country	Number of universities	Name of university	Rank
1	Serbia	2	University of Belgrade University of Novi Sad	401–500 901–1 000

Table 5 Position of universities from selected countries for comparison in the 2019 ARWU list

Country	Rank of university 1–100	Rank of university 101–500	Rank of university 501–1 000
Switzerland	5	3	2
Sweden	3	8	2
Denmark	2	5	1
Finland	1	4	5
Norway	1	3	3

which is about 2% of the total number of universities in the world (Docampo 2013; Živkovic et al. 2017b). The criteria that make a university prestigious in the world and which measure the quality of education are the number of graduates who are winners of the Nobel Prize and Medal in scientific fields (Alumni); quality of the faculty; the number of employees who won the Nobel Prize or Medals in scientific fields (Award); number of highly cited scientists from 21 scientific fields (HiCi); results of scientific research: number of papers published in the journals Nature and Science (N&S); number of papers publiched in SCIe and SSCI journals; per capita academic performance of a institution (Docampo 2013; Saarela et al. 2016; Živković et al. 2017a, b).

Each year, the ARWU lists the 500 first universities for a given year based on the results achieved by the above criteria in the previous year (http://shanghairanking.com/ARWU2019.html. Accessed 10 December 2019). Also, a list of 501–1 000 universities in the world among which candidates for the top 500 are recognized is published. The results for 2019 for WB countries are shown in Table 4.

The obtained results indicate that, from the WB countries, only the University of Belgrade (UB) is on the ARWU list, between 401 and 500 places, and the University of Novi Sad at 901–1000. UB has been in the top 500 on the ARWU list since 2012. Universities from other WB countries are not ranked among the top 1000 in the world by ARWU criteria.

For comparison, Table 5 shows the position of the universities of comparative countries (Table 1) on the 2019 ARWU list.

These facts best illustrate the correlation between the quality of the university and the development of the country, which is reflected in quality of life, height of standards, quality of health and everything else that is important for the life of the population, and, among other things, developed democracy and political freedoms by world standards (Fleig-Palmer and Schoorman 2011). In this way, graduates provide adequate answers to the requirements of the contemporary environment and contribute to the development of their countries, with their professional knowledge and skills acquired during university education (Maciel-Monteon et al. 2020). Also, in some scientific fields, universities from all over the world are ranked, which indicates the development of certain disciplines in them.

These facts also clearly indicate the development of scientific work in certain scientific disciplines at the ranked universities, which have largely influenced the final position on the ARWU list. Table 6 shows the rank of universities from WB countries in individual areas up to position 500 (http://shanghairanking.com/Shanghairanking-Subject-Rankings/index.html. Accessed 10 December 2019).

In the fields of Chemistry, Electrical, and Electronic Engineering, Computer Science and Engineering there are no universities in the top 500 countries. In the field of Economics, Political Science, Law, Management Finance, there are also no universities in the top 500, which clearly indicates that these areas are inadequately developed in the WB countries compared to those in the developed world.

One of the criteria for ranking universities in the ARWU list is the number of highly cited scientists from 21 scientific fields (HiCi)—20%. Clarivate Analytics has produced a Highly Cited Researchers list, which gives an overview of the most cited people in 2018 for 21 scientific fields (*Agricultural Science; Biology & Biochemistry; Chemistry; Clinical Medicine; Computer Science; Economics & Business; Engineering; Environmental/Ecology; Geosciences; Immunology; Materials Science; Mathematics; Microbiology; Molecular Biology & Genetics; Neuroscience & Behavior; Pharmacology/Toxicology; Physics; Plant & Animal Sciences; Psychiatry/Psychology; Social Sciences, General; Space Science*), as well as *Cross-field* (22nd field). For citation data, the Web of Science database is used. The result of the most cited researchers in 2018 included about 4000 researchers for 21 areas and about 2000 for Cross-field (Clarivate Analytics 2019). The results of the most quoted people in the world in 2018 from WB countries are shown in Table 7.

By comparison, in seven randomly selected scientific fields (Chemistry, Clinical Medicine, Computer Science, Economics & Bussines, Materials Science, Physics and

Table 6 Ranking of universities from WB countries in individual scientific fields for 2019

Number	Country	Number of universities	Name of university	Rank
Mathematics				
1	Serbia	1	University of Kragujevac	401–500
Physics				
2	Serbia	1	University of Belgrade	201–300
Chemical Engineering				
5	Serbia	1	University of Novi Sad	401–500
Veterinary Sciences				
1	Serbia	1	University of Belgrade	201–300
Clinical Medicine				
2	Serbia	2	University of Belgrade University of Kragujevac	201–300 201–300
Public Health				
2	Serbia	1	University of Belgrade	151–200
Mining and Mineral Processing				
1	Serbia	1	University of Belgrade	76–100
Metallurgical Engineering				
1	Serbia	1	University of Belgrade	151–200

Table 7 The most cited researchers in 2018 in 21 areas and cross-field according to Clarivate Analytics for WB countries

Number	Country	Researcher and institution	Scientific field
1	Serbia	Stojan Radenović, University of Belgrade (secondary affiliation); King Saud Saudi Arabia University (primary affiliation)	Mathematics

Cross-field) among the most cited researchers in 2018, in countries comparable in population to WB countries, the situation is as follows (Clarivate Analytics 2019):

- Switzerland—56 researchers,
- Denmark—36 researchers,
- Sweden—36 researchers,
- Finland—5 researchers,
- Norway – 4 researchers.

From all universities and scientific institutions in WB countries in all 21 areas and Cross-field, according to Clarivate Analytics, only one name appears, with dual affiliation, which has not been active and has been retired for several years (Table 7).

The results clearly indicate that higher education in WB countries is at a relatively low level compared to developed countries and that it does not represent a priority for political elites who led the WB countries. In institutions responsible for the development of education, there are often people who have not achieved any visible international influence (most of them have no articles in SCIe, SSCI, and A&HCI journals and certainly no citation). The process of accreditation and obtaining work permits is conducted more formally, and most professors at private colleges and universities have also acquired their education at them, with a low level of knowledge and competencies. No matter what they sign with Prof. PhD (the vast majority have no papers in SCIe, SSCI, and A&HCI journals, no citations and no international collaboration and reputation). Most doctoral theses in private colleges are at the level of seminary papers in serious schools and without verifying the results obtained in journals from SCIe, SSCI or A&HCI lists. In such conditions, the transfer of knowledge, from professors without knowledge, to students who come with little knowledge from the previous level of education (PISA test results), creates bad staff, which later, due to lack of knowledge, cause great harm wherever they are employed, because they do not possess the competencies and skills required by the global environment (Fleig-Palmer and Schoorman 2011; Avelar et al. 2019). In almost all WB countries, buying degrees, plagiarizing doctoral theses, etc. is becoming a normal practice. There are ministers in the governments with plagiarized doctorates with no moral obligation to resign. Many members of the Government and those in high positions in the state administration and state-owned enterprises of national interest have acquired diplomas from private faculties in an accelerated procedure, without adequate knowledge and competencies of the profession they "studied".

Education is not a priority of political elites in WB countries, which is why allocations for this most important development segment of society (Goksu and Goksu 2015) are less than 1% of GDP. Developed countries allocate much more to education, for example, Denmark 7.9%; Sweden 6.8%; Finland 6.3%, Norway 5.5%; Greece 4.2%. Moreover, the GDP nominal value of the mentioned countries is much higher than the GDP nominal values of the WB countries, so the available funds are much higher (Vilić 2014).

Due to the low quality of education at all levels, WB countries have a vassal position in relation to other countries, especially those in the EU, because the level of knowledge is incomparable and does not allow equal business cooperation and partnership. Figure 1 schematically shows the relationship in the negotiation process of two countries (or two companies) with an approximate level of knowledge when the outcome is an equitable business partnership.

Figure 2 shows the negotiation process and the possible business relationship of two countries (or two companies) with a drastic difference in the level of knowledge, where a positive outcome of the negotiation process is only possible if a partner with less

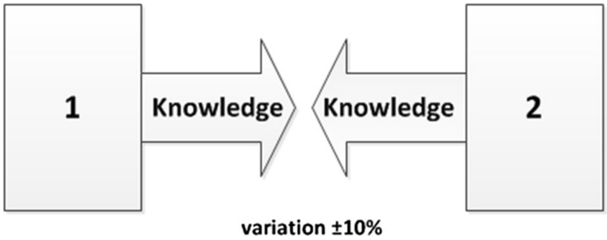

Fig. 1 Model of the negotiation process between the two countries or two companies with approximately the same level of knowledge

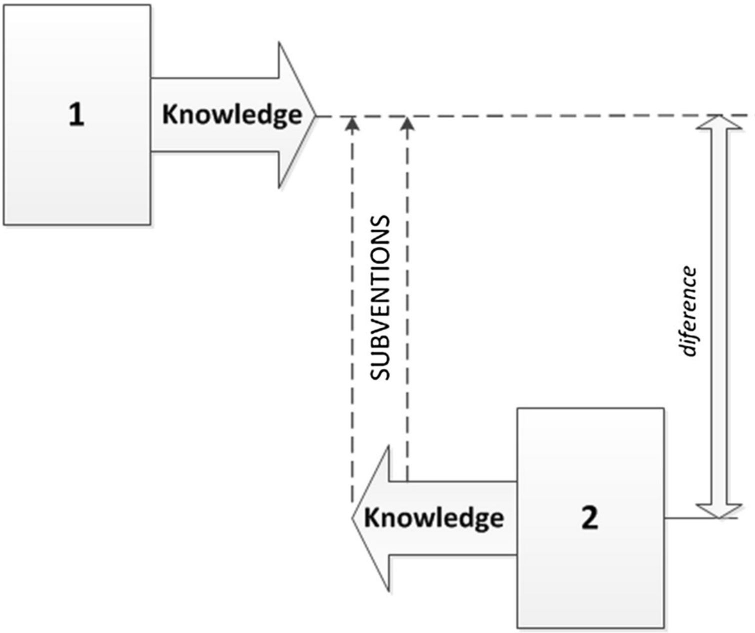

Fig. 2 Model of the negotiation process between the two countries or two companies with different levels of knowledge

knowledge gives subsidies to a partner with greater knowledge and the ability to invest using resources of partner with less knowledge: cheap labor, natural resources, and subsidies. As a result of such unequal business cooperation, simple technologies are invested in low-knowledge countries (WB countries) where workers are trained for a short time in routine manual jobs with very low wages and an almost slave-owning attitude of a foreign employer towards the domestic workforce. All this leads to the mass abandonment of the country by young and best educated people and their departure to the countries of the Western Hemisphere, and more recently to China (Meyer 2001).

Quality of scientific work results

Scientists, by definition, publish their research results in scientific journals to be visible to researchers from around the world (Lane 2010), evaluated or cited for use in further research and thus experience internationalization (Lechuga and Lechuga 2012; Fiala et al. 2017). Many research institutions are launching scientific journals and scientific conferences, seeking to achieve the highest possible level and visibility in international scientific bases. This affirms the institution and the people who publish scientific publications or organize scientific conferences and creates opportunities for international cooperation and the creation of international scientific teams and better scientific results (Fang et al. 2012).

Table 8 gives an overview of the number of journal titles and scientific conferences published and organized by the WB countries, with the quality level Q1–Q4 according to the scientific base SJR–SCImago. The number of titles on SCIe and SSCI is much smaller, so the number of titles issued in WB countries is also much smaller (Falagas et al. 2018).

Published scientific results and their quality are measured in different ways, such as number of published papers on SCIe, SSCI, and SJR lists, number of papers cited, number of heterocytes, number of heterocytes per published paper, *h*-index and more. The above metric is published via GOOGLE SCHOLAR (GS), SCOPUS, JCR, etc. Metrics were performed for 239 countries for the period 1996–2018, according to the SCOPUS database and SJR lists of journals. Table 9 shows the ranking positions for WB countries (https://www.scimagojr.com/countryrank.php. Accessed 10 December 2019).

Scientific results in WB countries are somewhat visible in the STEM area (science, technology, engineering and math) (Hund et al. 2019), but the research findings in the field of social sciences are negligible. Researchers in this field in the WB countries justify this fact by the lack of opportunities for publication, which is far from the truth given the large number of international journals on the SSCI list (Jakobs 2010; Chou et al. 2013; Hicks et al. 2015).

Given that citation is the most reliable element in the metrics of the quality of scientific work (Hutchins et al. 2016; Cecile et al. 2017), Stanford University has long been concerned with this issue, and in August 2019 published a standardized method

Table 8 Number of published journal titles from the SJR List (SCImago) for 2019, by countries. The total number of indexed journals and conference proceedings in 2019 is 31,971. *Source*: SCOPUS database https://www.scimagojr.com/countryrank.php. Accessed 10 December 2019

Number	Country	Total number of indexed sources	Q_1	Q_2	Q_3	Q_4	Conference proceedings
1	Serbia	63	2	9	29	22	1
2	Bosnia and Herzegovina	11	–	1	6	4	–
3	Northern Macedonia	6	–	–	3	3	–
4	Montenegro	4	–	1	2	1	–
5	Albania	0	–	–	–	–	–
6	Kosovo*	0	–	–	–	–	–
Selected countries' position for comparison							
1	Switzerland	584	154	171	149	103	7
2	Finland	51	5	14	14	15	3
3	Sweden	50	7	17	11	11	4
4	Denmark	43	5	5	10	19	4
5	Norway	31	2	5	8	16	–

Table 9 Ranking of WB countries by published results of scientific work for all fields of science according to the SCOPUS database for the period 1996–2018 and SJR (SCImago) Journal List

Country number in the world	Country	Number of published papers	Number of papers cited	Number of citations	Number of self-citations	Number of citations per paper	h-index
52	Serbia	91,280	86,176	781,607	152,621	8.56	220
94	Bosnia and Herzegovina	12,226	11,504	70,210	7956	5.74	91
95	Northern Macedonia	11,949	11,312	109,734	10,501	9.81	108
119	Albania	4727	4445	30,255	2590	6.40	62
124	Montenegro	3920	3687	21,019	4227	5.36	51
	Kosovo*	–	–	–	–	–	–
Selected countries' position for comparison							
16	Switzerland	710 672	648,991	19,461,396	2,459,376	27.38	919
18	Sweden	655 869	604,085	16,383,158	2,356,818	24.98	825
23	Denmark	393 204	357,963	10,115,806	1,353,641	25.73	620
26	Finland	334 763	311,398	7,553,739	1,078,823	22.56	609
30	Norway	312 012	289,277	6,447,670	943,274	20.76	580
Top ranked country							
1	USA	12,070 144	10,701,848	297,655,815	134,368,758	24.66	2222
Worst ranked country							
239	Heard Island and McDonald Islands	2	2	9	0	4.5	1

A total of 239 countries are ranked

of citation measurement that did much to avoid abuse in citing and publishing scientific papers that are present all over the world, and are widely expressed in WB countries (false co-authorships, false quotes on the principle of "I will do for you—you will do for me") (Živković 2018).

Based on a standardized citation measurement methodology (Ioannidis et al. 2016), a so-called composite indicator (c) has been defined at Stanford University, and lists of the world's most cited researchers for the period 1996–2017 (ranked 104,051 researchers) and 1996–2018 (ranked 105,000 researchers) using the WoS database are published. The obtained results for the WB countries are shown in Table 10. It can be seen that no researchers were ranked from Northern Macedonia, Bosnia and Herzegovina, Albania and Kosovo* (Ioannidis et al. 2019). For the period 1996–2017, nine researchers were ranked from Serbia and only one from Montenegro. For the period 1996–2018, thirteen researchers were ranked from Serbia and two from Montenegro. There are no ranked researchers from other countries in the WBs according to the methodology mentioned. The number of ranked scientists from the comparative countries, as well as their positions, in a very striking way indicate the position of science in the WB countries relative to the developed EU countries.

Given that from the WB countries, many scientists have gone to the developed world (EU and US universities) to work and create there, it is logical to expect that diaspora scientists would collaborate with counterparts in their home countries (Meyer 2001; Meyer and Wattiaux 2006; Finegold et al. 2019). In the case of WB countries, there are only sporadic cases (Tejada 2013) due to the dramatic difference in the level of laboratory equipment and the level of available knowledge, as well as the lack of interest of home countries in the WB for this form of cooperation with the diaspora. From Serbia, for example, a number of scientists in the Western Hemisphere are ranked high on the list, such as Vunjak-Novaković Gordana (Columbia University, USA) with position 14,920, and Zoran Živković (NXP Semiconductors, Einhoven, Netherland) with position 75,526 (as of 2017).

Possible options to improve the quality of science and education in the WB countries

The new format for EU negotiations with WB countries on meeting EU standards for accession to the EU implies approximation only in those areas where WB countries have made some progress in the level of acquired knowledge and fulfilled standards, which enables active application for EU integration (Fig. 1) (Gaus 2008).

In order to achieve the same level of knowledge in the WB countries compared to the level of knowledge in the developed EU countries, it is necessary for the ruling elites in the WB countries to make education and science the most important development priority in their countries (Maciel-Monteon et al. 2020), which entails a dramatic rethinking of the accreditation of all colleges and universities according to the highest EU standards, as well as spending more than the EU average on science and education (3.5% of GDP) (Goksu and Goksu 2015; Gavine et al. 2019).

The implementation of the seven dimensions of BPEP (Leadership, Strategy, Customer, Workplace, Operations, Measurement, Analysis, and Knowledge Management (MAKM) and Results) in all higher education organizations is necessary as a first step to increase the quality of higher education outputs (NIST 2017).

Table 10 Ranking of researchers from around the world (first 105,051 for 1996–2017) and first 105,000 for 1996–2018) by Stanford University Citation Standards (data for WB)

Number	Country	Year	Total number of ranked	Position of best ranked	Name of researcher	Institution	Scientific field
1	Serbia	2017	9	6126	Ivan Gutman	University of Kragujevac	General Chemistry
		2018	13	4438	Ivan Gutman	University of Kragujevac	General Chemistry
2	Montenegro	2017	1	39,073	Ljubiša Stanković	University of Montenegro	Networking and Telecommunications
		2018	2	41,049	Ljubiša Stanković	University of Montenegro	Electrical and Electronic Engineering
Selected countries' position for comparison							
1	Switzerland	2017	1695	1	Grätzel Michael	Ecole Polytechnique Federale de Lausanne (EPFL)	General Chemistry
		2018	1856	32	Reed John	F. Hoffman-La Roche AG	Biochemistry and Molecular Biology
2	Sweden	2017	1659	212	Van Heijne Gunnar	Stockholm University	Biochemistry and Molecular Biology
		2018	1706	295	Van Heijne Gunnar	Stockholm University	Biochemistry and Molecular Biology
3	Denmark	2017	998	323	Holst Jenst	University of Copenhagen	Ednocrinology and Metabolism
		2018	1023	122	Mann Matthias	University of Copenhagen	Biochemistry and Molecular Biology
4	Finland	2017	620	429	Laaksao Markku	University of Eastern Finland	Endocrinology and Metabolism
		2018	706	505	Laaksao Markku	University of Eastern Finland	Endocrinology and Metabolism
5	Norway	2017	441	1057	Oxman Andrew	Norwegian Institute of Public Health	General and Internal Medicine
		2018	539	513	Lande Rusell	Norwegian Institute of Science and Technology	Evolutionary Biology

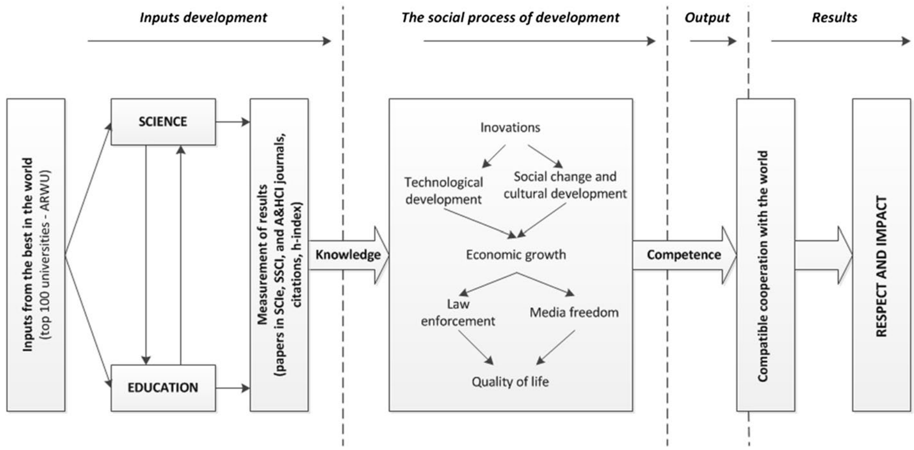

Fig. 3 The process of developing a country on the road to a respectable position in the world

The stated goal can be achieved through the process of developing the country on the way to a respectable position in the world (Fig. 3), which has several stages:

(a) Inputs for knowledge creation
(b) The social process of development
(c) Output—competencies
(d) Results—respectable influence in the world.

Inputs for knowledge creation

Universities with a high level of graduates' knowledge output represent the best resource for the development of each state, its society as a whole, science, economics, technology, industry, politics, etc. (Dlouhá et al. 2017; Maciel-Monteon et al. 2020). The direct interaction of education and science in the process of knowledge creation in one country is evident (Maciel-Monteon et al. 2020). In order to create competent scientists and professors for all levels of education in a number of generations, it is necessary to continuously provide quality education, especially university one (Austin 2002; Lavalle and de Nicolas 2017). At the same time, it is not possible to have a quality education, especially a university one, without developed science. Therefore, in developed countries, special attention is paid to doctoral and postdoctoral studies (O'Meara et al. 2013). The quality of university education depends on the quality of transferring the latest knowledge in a given field, which is only possible at a university with advanced science. Teaching at the university can not only be restricted to classic textbooks, but it must be done by active scholars, who are able to pass on the latest achievements to their students (Ioannidis 2015).

More recently, models of effective MCP (*Mentoring Circles Program*) mentoring have been developed at US universities, peer-to-peer, with individuals with diverse backgrounds and scientific knowledge to adequately educate students and create international networks at all levels of study, from elementary to postdoctoral. The ultimate goal is to create successful student careers based on the quality of the knowledge gained (Opengart and Bierema 2015; Kuhn and Castano 2016; Hund et al. 2019). This principle works well in the

US and Japan, making these countries with distinctive competencies in the modern world (Johanson 2015; Lynch 2017). In principle, the answer to all challenges is given by science, which directly affects the development of each country, the quality of life of its citizens and its credibility in the world (Lynch 2017).

Given the current position of higher education and science levels in WB countries, the process of reaching the levels of developed EU countries (selected countries comparable in population) cannot go spontaneously—this would be contrary to the principles of the First Law of Thermodynamics (Živković and Savović 1994). In order to achieve this goal, it is necessary to intensify the cooperation of universities in WB countries with the best universities in the world (top 100, for example). From every university, tens of students, doctoral students, and postdoctoral students should be sent to spend some time at these top universities, acquire adequate knowledge, learn the necessary skills and establish international contacts and cooperation with the best in the world. In this way, when they return to their universities, they will bring knowledge and international cooperation, which will raise the level of development of science and education at WB universities. The evaluation of the success of this step is the quality of knowledge generated by science and education, which is measured by the number of papers on SCIe, SSCI, A&HCI (Chou et al. 2013), and SJR lists (Falagas et al. 2018), the number of citations (Yong 2014), h-index (Hirsch 2005a, b; Blaise and Lokman 2006) and h_m-index (Schreiber 2008) in all fields, which must be at the same level as in developed EU countries with the same population (Waltman and van Eck 2012; Živkovic 2019). A prerequisite for generating the expected results is the unconditional application of BPEP through the NIST standard (NIST 2017).

The social process of development

With the achieved level of knowledge in all fields (natural sciences, technical sciences, medical sciences, and social sciences) as well as in developed EU countries, conditions are created for the spontaneous process of creating innovations that lead to the development of technological processes, social changes, and cultural development, leading to economic growth of the country that creates the environment for the implementation of EU laws and media freedoms, which ultimately creates the conditions for increasing the quality of life in WB countries. By generating graduates from higher education institutions with the professional knowledge, skills, and competencies required by the current global environment, the conditions for the democratic development of a country based on knowledge recognized worldwide have been created (Ah-Teck and Starr 2013).

Competence at all levels

Through a spontaneous, knowledge-based country development process, the output is to create the competence of all the country's resources at all levels, analogous to developed EU countries. In such a situation, the interest of young and educated people to pursue a career in the developed west is diminished due to the challenge of achieving analogous results in their own country. In these circumstances, human potential, as the most significant resource of any country, is growing, which creates realistic opportunities for sustainable growth and development over a long period of time (Lavalle and de Nicolas 2017). In these circumstances, WB countries become equal partners in business negotiations with developed EU countries, and possible cooperation is achieved instead of at the vassal level, on an equal partnership basis (Fig. 1).

Results: respectable impact in the world

After building partnerships with developed EU countries and around the world, WB countries become recognizable as they are capable of competent cooperation with the developed world, and with the less developed in particular. In this way, in addition to increasing opportunities for entry into the EU, WB countries are becoming respectable partners with the whole world, which creates the conditions for equal cooperation and export of acquired knowledge through new technologies and innovations all over the world. These results represent a sure-fire path to achieving the WB countries' goals of improving economic growth, retaining creative people in their countries, developing democratic relations at all levels and ensuring a high quality of life for their populations.

Conclusion

The results clearly indicate that education at all levels and science in WB countries are at a relatively low level, with a tendency to decline compared to developed EU countries. This situation is a consequence of the disinterest of political elites in the WB countries for the development of science and education. There is a trend towards the opening of private colleges and universities creating 'local' level knowledge, which is not comparable to that in developed EU countries (symbolic number of publications in SCIe, SSCI, and A&HCI journals by teaching staff and graduates).

The initiative of the leaders of Serbia, Northern Macedonia and Albania, joined by the leader of Montenegro, on the creation of the so-called The "small Schengen", which implies free movement of goods, labor, and capital, has a real chance of succeeding (model in Fig. 1), given approximately the same level of knowledge of the ruling elites in these countries, education, and training of the workforce, as well as the level of employed technology in all spheres of society. There is a real danger of complacency with the initial positive results, which can further disassociate WB countries from the EU by neglecting the development of science and education.

In order to create the conditions for equal negotiation and equal business relations with the EU, it is necessary to raise the level of knowledge and science to the same level as in developed EU countries. This cannot be done declaratively, but by clearly defining political elites in these countries for adequate spending on education and science at least at the EU average level and above.

The process of creating competencies and respectable influence in the world is not realized spontaneously. Learning from the best in the world is the only realistic way to achieve international competencies that can best be judged by the international metric of scientific output, which is the basis for the development of quality education.

Raising the level of education and science in WB countries to the level of developed EU countries is a necessary and sufficient condition for partnership negotiations on the entry of WB countries into the EU, stopping brain drain from WB countries, as well as their economic development at EU level, which creates conditions for adequate quality of life for people in these countries. In these conditions, WB countries can become respectable partners to other countries around the world, which enhances the export opportunities of technologies and innovations created in WB countries. So, instead of attracting foreign investors who bring simple technologies with subsidies from the WB countries, the development of knowledge creates the conditions for the development of their own modern technologies and export of knowledge worldwide.

References

Ah-Teck, J. C., & Starr, K. (2013). Principals perceptions of "quality" in Mauritian schools using the Baldrige framework. *Journal of Educational Administration, 51,* 680–704.

Albuquerque, E. M. (2016). Science and technology system in less development countries. In *Handbook of quantitative science and technology research* (pp. 759–778).

Austin, A. E. (2002). Preparing the next generation of faculty: Graduate school as socialization to the academic carier. *The Journal of Higher Education, 73,* 94–122.

Avelar, A. B. A., da Silva-Oliveira, K. D., & da Pereira, R. S. (2019). Education for advancing the implementation of the sustainable development goals: A systematic approach. *The International Journal of Management Education, 17,* 100322–100331.

Bak, H. (2018). Beyond the economy: Education for development. *Kasetsart Journal of Social Sciences*. https://doi.org/10.1016/jkjss.2018.06.001.

Barabási, A. I., Jeong, H., Néda, Z., Ravasz, E., Schubert, A., & Vicsek, F. (2002). Evaluation of the social network of scientific collaborations. *Physica A: Statistical Mechanics and its Applications, 311*(3), 590–614.

Beaver, D., & Rosen, R. (1979). Studies in scientific collaboration, part III scientific co-authorship, research productivity and visibility in the French scientific elite, 1799–1830. *Scientometrics, 1*(2), 133–149.

Blaise, C., & Lokman, I. M. (2006). Using the h-index to rank influential information scientists. *Journal of the American Society for Information Science and Technology, 57*(9), 1275–1278.

Cecile, A., Janssens, J. W., Goodman, M., Powell, K. R., & Gwinn, M. (2017). A critical evaluation of the algorithm behind the relative citation ratio (RCR). *PLoS Biology, 15*(10), 2002536.

Chou, C. P., Lin, H. F., & Chiu, Y. (2013). The impact of SSCI and SCIe on Taiwan's academy: An outcry for fair play. *Asia Pacific Education Review, 14*(1), 23–31.

Clarivate Analytics (2019). Highly Cited Researchers. Web of Science Group.

Daraio, C., Bonaccorsi, A., & Simar, L. (2015). Ranking and university performance: A conditional multidimenzional approach. *European Journal of Operational Research, 224*(3), 918–930.

Dlouhá, J., Glavič, P., & Barton, A. (2017). Higher education in Central European countries—Critical factors for sustainability transition. *Journal of Cleaner Production, 151,* 670–684.

Docampo, D. (2013). Reproducibility of the Shanghai academic ranking of world universities results. *Scientometrics, 94*(2), 567–587.

Dumciuviene, D. (2015). The impact of education policy to country economic development. *Procedia—Social and Behavioral Sciences, 191,* 2427–2436.

Falagas, M. E., Kouranos, V. D., Arencibia-Jorge, R., & Karageorgopoulos, D. E. (2018). Comparasion of SCImago journal rank indicator with journal impact factor. *The FASEB Journal, 22*(8), 26–28.

Fang, F. C., Steen, R. G., & Casadevall, A. (2012). Misconduct accounts for the majority of retracted scientific publications. *Proceedings of the National Academy of Science, USA, 109*(42), 17028–170033.

Fiala, J., Mareš, J. J., & Šestak, J. (2017). Reflections of how to evaluate the professional value of scientific papers and their corresponding citations. *Scientometrics*. https://doi.org/10.1007/s11192-017-2334x.

Finegold, D., Venkatesh, K., Winkler, A., & Argod, V. (2019). Why they return? Indian students in the United States. *Economic and Political Weekly, 46*(21), 21–25.

Fleig-Palmer, M. M., & Schoorman, F. D. (2011). Trust as a moderator of the relationship between mentoring and knowledge transfer. *Journal of Leadership & Organizational Studies, 18,* 334–343.

Gaus, G. (2008). On philosophy, politics and economics (Wadsworth Philosophical Topics).

Gavine, A., MacGillivray, S., McConville, F., Gandhi, M., & Renfrew, M. J. (2019). Pre-service and in-service education and training for material and newborn care poroviders in low-and middle-income countries: An evidence review and gap analysis. *Midwifery, 78,* 104–113.

Goksu, A., & Goksu, G. G. (2015). A comparative analysis of higher education financing in different countries. *Procedia Economics and Finance, 26,* 1152–1158.

Goldberg, J. (1998). What is role of science in developing countries? *Science, 279*(5354), 1140–1141.

Habibov, N. N., & Cheung, A. (2017). The role of university education in selecting active strategies for coping with the 2007 global crisis in 28 transitional countries. *International Journal of Educational Development, 57,* 65–72.

Hicks, D., Wouters, P., Waltman, L., de Rijcke, S., & Rafols, I. (2015). Bibliometrics: The Leiden manifesto for research metrics. *Nature, 520,* 429–431.

Hirsch, J. E. (2005a). An index to quality an individual's scientific research output. *Proceedings of the National Academy of Science, USA, 102,* 16569–16572.
Hirsch, J. E. (2005b). Does h-index have predictive power? *PANS, 104*(49), 19193–19198.
Holm, T., Sammalisto, K., & Vuorisalo, T. (2015). Education for sustainable development and quality assurance in universities in China and Nordic countries: A comparative study. *Journal of Cleaner Production, 107,* 529–537.
Hund, A. K., Churchill, A. C., Faist, A. M., Havrilla, C. A., Love Stowell, S. M., McCreery, H. F., et al. (2019). Transforming mentorship in STEM by training scientists to be better leaders. *Ecology and Evolution, 8,* 9962–9974.
Hutchins, B. I., Yuan, X., Anderson, J. M., & Santangelo, G. M. (2016). Relative citation ratio (RCR): A new metric that uses citation rates to measure influence at the article level. *PLoS Biology, 6,* 1–25.
Ioannidis, J. P. A., Fanelli, D., Dunne, D. D., & Goodman, S. N. (2015). Meta-research: Evaluation and improvement of research methods and practices. *PLoS Biology, 2,* 1–7.
Ioannidis, J. P. A., Klavans, R., & Boyack, K. W. (2016). Multiple citation indicators and their composite across scientific discipline. *PLoS Biology, 1,* 1–17.
Ioannidis, J. P. A., Bass, J., Klavans, R., & Boyack, K. W. (2019). A standardized citation metrics author database annotated for scientific field. *PLoS Biology, 2,* 1–6.
Jakobs, D. (2010). Demystification of bibliometrics, scientometrics, informetrics and webometrics. In *11th DIS annual conference*, Richardsbay, proceedings (pp. 1–18).
Johanson, W. B. (2015). *On being a mentor: A guide for higher education faculty* (2nd ed.). New York: Taylors & Francis.
Kolb, M., Fröhlich, L., & Schmidpeter, R. (2017). Implementing sustainability as the new normal: Responsible management education—From a private business school's perspective. *The International Journal of Management Education, 15*(2), 280–292.
Kuhn, C., & Castano, Z. (2016). Boosting the career development of postdocs with a peer-to peer mentor circles program. *Nature Biotechnology, 34*(7), 763–781.
Lane, J. (2010). Let's make science metrics more scientific. *Nature, 464*(7288), 488–489.
Lavalle, C., & de Nicolas, V. L. (2017). Peru and its new challenge in higher education: Towards a research university. *PLoS ONE, 12,* e0182631.
Lechuga, V. M., & Lechuga, D. C. (2012). Faculty motivation and scholarly work: Self- determination and self-regulation perspectives. *Journal of the Professoriate, 6*(2), 1–12.
Li, J., Xi, T., & Yao, Y. (2019). Empowering knowledge: Political leaders, education and economic liberalization. *European Journal of Polytical Economy*. https://doi.org/10.1016/j.ejpoleco.2019.101823.
Lu, M., & Zhang, X. (2019). Towards an intelligent country: China's higher education expansion and rural children's senior high school participation. *Economic Systems, 43,* 100689.
Lynch, C. (2017). Communication strategies for managing conflict: A guide for academic leaders. *The Department Chair, 27*(3), 30–31.
Maciel-Monteon, M., Limon-Romero, J., Gastelum-Acosta, C., Baez-Lopez, Y., Tlapa, D., & Borbón, M. I. R. (2020). Improvement project in higher education institutions: A BPEP-based model. *PLoS ONE, 3,* 1–19.
Meyer, J.-B. (2001). Network approach versus brain drain: Lessons from diaspora. *International Migration, 39*(5), 91–110.
Meyer, J.-B., & Wattiaux, J.-P. (2006). Diaspora knowledge networks: Vanishing doubts and inceasing evidence. *International Journal of Multicultural Societies, 8*(1), 4–24.
Milovantseva, N., Earle, A., & Heymman, J. (2018). Monitoring progress toward meeting the United Nation SDG on pre-primary education: An important step towards more equitable and sustainable economies. *Internatonal Organisations Research Journal, 13*(4), 137–158.
NIST—National Institute of Standards and Technology. (2017). *Baldrige excellence framework (Education)*. Gaithersburg: United States Department of Commerce.
O'Meara, K., Knudsen, K., & Jones, J. (2013). The role of emotional competencies in faculty-doctoral student relathionships. *The Review of Higher Education, 36*(3), 315–347.
Opengart, R., & Bierema, L. (2015). Emotionally intelligent mentoring: Reconceptualizing effective mentoring relationships. *Human Resource Development Review, 14*(3), 234–258.
Saarela, M., Kärkkäinen, T., Lahtonen, T., & Rossi, T. (2016). Expert-based versus citation based ranking of scholarly and scientific publication channels. *Journal of Informetrics, 10*(3), 693–718.
Schreiber, M. (2008). To share the fame in a fair way, h_m modifies h for multi-authored manuscripts. *New Journal of Physics, 10,* 040201.
Sulis, I., Giambona, F., & Porcu, M. (2019). Adjusted indicators of quality and equity for monitoring the education systems over time: Insights on EU15 countries from PISA surveys. *Economics*. https://doi.org/10.1016/j.seps.201905.005.

Tejada, G. (2013). Scientific diasporas fostering science and technology in the home countries. In *Proceedings of international conference on science and technology for economic diversification—INSCITED 2013*, Port of Spain, Trinidad, June 5–7, pp. 1–29.

United Nations. (2018a). *Sustainable development goals*. Accessed November 2018.

United Nations. (2018b). Transforming our world: The 2030 agenda for sustainable development (2015). Accessed November 2018.

Vilić, D. (2014). Role of knowledge and education in modern society. *Politeia, 8,* 389–405. **(in serbian)**.

Waltman, L., & van Eck, N. J. (2012). The incosistency of the h-index. *Journal of the American Society for Information Science and Technology, 63,* 406–415.

Yau, H. K., & Cheng, A. L. F. (2013). Quality management in primary schools. *International Education Research, 1*(4), 16–31.

Yong, A. (2014). Critique of Hirsch's citation index: A combinatorial Fermi problem. *Notice of the American Mathematical Society, 61,* 1040–1050.

Zhou, N., & Lu, H. (2018). A review and comparison of midwifery management and education in five representative countries. *International Journal of Nursing Sciences, 5,* 10–14.

Živković, Ž. (2018). New inovative approach in the development and publishing of scientific papers—Creation of new ''scientific elite'' in countries with transitional economy. In *Fifth international science conference, contemporary management challenges and the organizational challenges*, Bitola (Macedonia) 8–12.11., Book of Abstracts, p. 55.

Živković, Ž. (2019). Ranking of researchers based on the achieved scientific results (Case study: Technical Faculty in Bor, University of Belgrade, Serbia). *Trendovi u poslovanju, 13*(2), 9–22. **(in Serbian)**.

Živković, Ž., & Savović, V. (1994). *Principles of the metallurgical thermodynamics*. Technical Faculty in Bor (**in Serbian**).

Živković, Ž., Arsić, M., & Nikolić, D. (2017a). The University of Belgrade on ARWU list—Part I: The impact of individual faculties on the achieved position using PROMETHEE-GAIA Method. *Serbian Journal of Management, 12*(2), 171–187.

Živković, Ž., Arsić, M., & Nikolić, D. (2017b). The University of Belgrade on ARWU list: Part II The impact of individual research institutes on the achieved position using PROMETHEE-GAIA Method. *Acta Oeconomica Universitatis Selye, 6*(1), 167–179.

Internet sources

Retrieved December 10, 2019 from https://en.wikipedia.org/wiki/List_of_countries_by_population_growth_rate.

Retrieved December 10, 2019 from https://www.scimagojr.com/countryrank.php.

Retrieved December 10, 2019 from https://en.wikipedia.org/wiki/Programme_for_International_Student_Assessment.

Retrieved December 10, 2019 from http://shanghairanking.com/ARWU2019.html.