Big Data and International Accreditations in Higher Education: A Dutch – Russian Case Study

Florentin Popescu[1][a], Roman Iskandaryan[2][b] and Tijmen Weber[1][c]
[1]*HAN University of Applied Sciences, Ruitenberglaan 31, 6826 CC, Arnhem, The Netherlands*
[2]*Plekhanov Russian University of Economics, Stremyannyy Pereulok, 36, Moscow, Russia*

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Abstract: This comparative study paper seeks to document how with the help of Big Data different aspects of International Accreditations are perceived by both Plekhanov Russian University of Economics and HAN University of Applied Sciences (Arnhem Business School), the Netherlands faculty and higher management. This paper is looking at bringing advice and helping the chosen universities with their international accreditations processes by demonstrating the importance of Big Data. The importance of Big Data and International Accreditations to both universities will be accounted for in this paper. In comparison to current research on Big Data in higher education, this work focuses on the goal of preparing the universities for future academic international accreditations. It is a comparative study where is meant to learn from best practices rather than to generalize and extrapolate results. On a conceptual way, this paper contributes to knowledge by attempting to develop a strategic planning of the international accreditations process by determining the best practices using Big Data while creating a process for internationalization to increase the universities' global competitiveness.

1 INTRODUCTION

Big data refers to amounts of data that are being collected which are so enormous that they cannot be analysed using conventional statistical techniques (Dunham, 2014). This development has occurred because technology is increasingly adapted so it can effectively collect data, even if it is not directly used. As an untapped resource, big data is becoming increasingly valuable because it provides a very cost-effective means of gathering data and drawing conclusions (Dunham, 2014). Educators have also started to take note to this development which has opened new areas of didactic techniques and research possibilities (West, 2012). Why not use Big Data in helping with the International Accreditations?

According to the fourth Global Survey of International Association of Universities 89% of universities worldwide claim to have an institutional policy or to have implemented internationalization within their overall strategy, and 22% are preparing an internationalization strategy (Egron-Polak and Hudson, 2014). With the increase of globalization in education, which manifests in a growing number of foreign students and teachers, double degree programs and joint research projects the importance of international accreditations significantly, rises (Iskandaryan, 2018).

The analysis of policies, institutional structure and operation help administrators make improvements at the management level (Daniel and Butson, 2013) while higher education institutions are able to determine variables affecting student retention and program completion (Wagner and Ice, 2012).

E-learning is already promoted as being important because provides a myriad of benefits to students such as flexibility and cost ease of access (Arkorful and Abaidoo, 2015), but with data collected on the answers students give on assignments it becomes increasingly possible to develop algorithms that can develop more personalized feedback (Belcadhi, 2016). A second advantage is that improving

[a] https://orcid.org/0000-0001-6119-5567
[b] https://orcid.org/0000-0003-4120-423X
[c] https://orcid.org/0000-0002-4956-5892

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curricula becomes more effective. Traditional course evaluation relies on the feedback of students, but with new data analytics is becomes possible to uncover how students interact with course contents (Reyes, 2015).

Big data can also be used to predict students' performance early on which can allow teachers to intervene and direct to attention to struggling students (Picciano, 2014; Reyes, 2015). Finally, big data opens up new forms of learning. Especially the area of blended learning has a lot to gain from this. Blended learning refers to combining online with traditional forms of learning and this is gaining because of its proven effectiveness (Porter et al., 2014). If blended learning platforms are offered on a widespread basis then the data that is gathered from this can be of major importance when it comes to developing new classes and understanding the behaviour of students.

Big Data analytics has also proven to be beneficial in the area of higher education especially in the decision-making process of institutions (Wagner and Ice, 2012; Daniel and Butson, 2013; Kellen, 2013).

According to Deepa and Chandra Blessie (2017), Big Data analytics will create a number of opportunities for the educational institution, administrators, policy makers, educationalists and also for the learners. These opportunities include:

1. Collaboration and comparisons among the institutions would become more comfortable.
2. Improved knowledge flow and learning success across the organization would be achieved.
3. Learning effectiveness would be improved through the self-measurement of learners and educators
4. Cost reduction through managing financial performance could be possible
5. The learning and academic risk and complexity could be reduced.

These developments are especially interesting because, if higher education institutions uses big data effectively, they can improve their quality of education but also experiment more leading to research opportunities in helping with International Accreditations.

For example, using a dashboard that integrates class materials, teacher instructions, online exercises, and peer feedback has much potential for not only enhancing learning experiences, it also allows staff and research to investigate indicators of education quality such as student engagement with the materials. Moreover, it also provides researchers the opportunity to experiment with various kinds of education techniques in a semi-controlled environment.

Through doing so, it becomes much easier and more effective to improve course contents which would boost the overall quality of the education institutions and help with International Accreditations.

2 PROBLEM DEFINITION AND RESEARCH DESIGN

The researchers encompass a consideration and evaluation of the specific universities policies and practices in relation to the theme and as well as an evaluation of institutional responses to a range of issues, policies and strategies concerning international accreditations and the use of Big Data. It positions the responses to internationalization process of chosen universities within the policy context that they set. It seeks to document how universities' management and faculty perceive different aspects and dimensions of international accreditations with the help of Big Data. In addition, this paper highlights some of the major issues in connection with institutional responses to the impact of internationalization with respect to responsibilities that range from being local to international in nature.

In line with these recommendations, the researchers chose a combination of interviews, archives, and observations, with main emphasis on the first two. In line with the explorative nature of the study, the goal of the interviews was to see the research topic from the perspective of the interviewee, and to understand why he or she came to have this particular perspective.

Policy and other documentation for the university was collected on site, to supplement the primary and secondary data gathered, when made and recorded. For the international policy context, sources of documentary information were used to scale the international, national and local position on higher education in selected universities. Several governments and other websites were used to glean policy and positional information. Sources referenced in research papers were also utilized as resources from online searches through various electronic databases and search engines. The documentation from institution was collected to gain insight into the institution and the strategies and policies in place.

Sources of this information included: strategic plans; management and academic structure charts; annual reports; internationalization policy documents; websites etc. These documents were the first types of units of observation.

There are many options available for analysing big data, but one that is clearly emerging in the field of higher education is known as Education Data Mining (EDM) (Romero and Ventura, 2010). In short, this method refers to using statistics, machine-learning, and data-mining algorithms in order to analyse the breadth of educational data that is being produced. Often the concept of EDM is used interchangeably with Learning Analytics, which is said to have the objective of understanding and optimizing learning and the environments in which learning occurs (Steiner et al., 2014). Because new education techniques such as e-learning and massive open online courses (MOOCs) are emerging (Hughes and Dobbins, 2015), there is an increasing demand for finding applications for this data. Although many applications are possible, here we will only discuss three in more detail and discuss some examples on how these have been applied.

One of the key applications is predicting student performance. Especially with international students it is difficult assess whether they will be successful because of the diversity in grading systems and the fact that their educational and cultural background is often unfamiliar to faculty and staff (Nghe et al., 2005). Therefore, it is important to find other ways of predicting the success and failure of students. Some of the most commonly used methods are neural-network models, Bayesian networks, and classification algorithms (Romero and Ventura, 2010). For example, Nghe et al (2015) used decision tree and Bayesian network algorithms to predict student GPA with as much as 94% accuracy.

Similarly, Shahari et al. (2015) found a 98% accuracy when using neural network analysis. However, their naïve Bayesian analysis only yielded a 76% accuracy. Many other examples are available as well, but the important implication of this technology is that it allows educators to intervene earlier making drop-out less likely.

Another application that is used is for the construction of more effective learning content. For example, McCusker et al. (2013) proposed a new adaptive educational environment where the learning style of students is determined based on their online behaviour which can then be used to create more personalized learning environments. Balogh et al (2013) on the other hand developed a method of assessing which study materials students were most likely to engage with. This has important applications as it can help teachers to more effectively determine which materials are most suitable or interesting to students.

Finally, social network analysis is emerging because of the fact that activity on social networks can quickly produce a large amount of information. Wen et al (2014), for example, were able to predict student dropout in MOOCs by looking at social media. Specifically, they were able to detect a significant correlation between drop-rates and the mood and sentiment about the course in discussion. Another important source of information is twitter feeds because it is very accessible to many people. Koutropoulos et al (2014) investigated the Twitter behaviours of students in online classes and were able to do sentiment analyses. Twitter was also used by participants for sharing information and troubleshooting problems between classes. Social networks can thus be utilized to both enhance the learning experience and allow educators to get better understanding of what people think of the course.

In the remaining sections we will describe and discuss how some of the aspects regarding EDM will be used, or already have been used, with the aim of facilitating the process of receiving an accreditation. Two education institutions are compared and we show how EDM and big data analysis finds various applications in both. Some of the problems in gathering relevant information can be overcome through EDM, but EDM is also used to satisfy criteria better.

3 RESULTS AND OUTCOMES

Society is more and more characterised by global and intercultural relationships, but also international challenges. Due to this, higher education should have a significant role in the society. Students should understand, be able to work and make their contribution to sustainable development at national and global levels and education should provide the prerequisites for this.

Intercultural and international dimensions are integrated into both the formal and informal curriculum into domestic e-learning environments by higher education institutions. Internationalisation at home is promoted by tools such as digital technology and virtual mobility. Those students who cannot benefit from physical international mobility opportunities may use these tools to create their own international contacts.

Since not all students will have the possibility to gain international experience through mobility, achieving intercultural understanding and international experience at home is necessary for students.

According to the needs of the institutions, government agencies have provided assistance for higher education institutions towards internationalisation. Internationalisation of higher education institutions brings benefits to almost all areas of society. Numerous organisations at various levels and within different areas have responsibility for the prerequisites for internationalisation and these prerequisites are also influenced by several policy areas. The internationalisation of higher education is particularly influenced by certain domains of society and related government agencies. These agencies should support each other and move in the same direction in order to put their efforts together. In order to manage effectively the challenges and barriers, the prerequisites of internationalisation must be consolidated through inter-sectorial cooperation. The key role in removing barriers through coordinated efforts belongs to the Ministry of Education and Research. The prerequisites for global cooperation are highly influenced by the national level in relation to international contacts. To consolidate bilateral relationships with certain countries and to promote Dutch research and higher education beyond the national borders, assuming a more operational role and coordinating the joint resources should be major roles of the Government. Considering the international competition, a more goal-oriented and stronger cooperation among Dutch higher education institutions may bring significant benefits.

A continued development by higher education institutions may be ensured by NVAO by bringing internationalisation to the forefront of the reviews executed by NVAO. The international activities of the institutions must be certified independently and prove that their efforts are in the positive direction.

Large data and relevant statistics must be accessed to obtain a relevant evaluation. Tracking of internationalisation and evaluation may be performed using the opportunities offered by NVAO, which includes review and statistical mandates. The continuous efforts towards increasing internationalisation may be supported on the basis provided by NVAO.

According to Ahmed (2016) who explored the factors necessary for Big Data implementation and provided understanding how enhance these factors in higher education accreditation using qualitative case study; there are six key factors essential for big data implementation in higher education accreditation:

- Security issues,
- Preserving privacy,
- Analytical skills,
- IT infrastructure,
- Top management support
- Collaborative information-sharing projects.

Now, HAN University of Applied Science is in the process of getting accredited by the European Foundation for Management Development for the EPAS accreditation program. The aim of EPAS is to evaluate the quality of business and/or management degree programs that have an international perspective (EFMD, 2018a). Interestingly, the achievement of several of the criteria can be aided by making good use of data technologies. Indeed, the HAN is already experimenting with such technologies, which have the potential of greatly increasing the quality of its education.

For example, in its curriculum several forms of blended learning are offered through the help of digital platforms such as those made available by Pearson and Khan Academy. When properly utilized these programs offer a distinct set of advantages, which fall in line with the criteria, set out by the EPAS program.

First, there is the advantage that it helps to satisfy the pedagogy criteria of EPAS (EFMD, 2018b, p.16) through offering blended learning and the use of modern technology. More significantly, however, is the potential these technologies have for helping students in a broader sense. Two important criteria of the EPAS are the personal development of students (EFMD, 2018b, p.17), and have more detailed ideas of the quality of student work (EFMD, 2018b, p. 20). Because with online platforms learning is done online, much data regarding the students' activities is gathered. This can then potentially be used to algorithmically generate individualized feedback, which is important for their learning process (Belcadhi, 2016).

Moreover, detailed statistics about the students' performance can easily be tracked which allows instructors to gain an overview of the progress that students are making. This can for example allow instructors to identify students who are struggling early on (West, 2012), but this data also hold potential for researchers because it opens up the possibility of finding patterns in learning behaviour and see how this correlates with specific characteristics of students.

A second important advantage that new technology brings is that it allows program review to go more effectively. Currently, students' reviews of staff and courses are done using standardized questionnaires, which are only administered a few times a year. However, as this article is being written, at HAN programs such as Evalytics are being piloted which allow instructors to very quickly ask students to answer a few simple questions in a matter of minutes. Such technologies make it possible to assess specific classes instead of whole courses, and it helps to improve the performance of instructors by giving more detailed feedback (Nunn et al., 2016). Because the timing of such reviews is also more spread out, there is also the advantage that it can potentially circumvent certain biases such as selection bias which has been found to influence course evaluation results (Wolbring and Treischl, 2016).

Plekhanov Russian University of Economics (PRUE) is a public higher educational institution founded in 1907. Its main campus is located in Moscow, and 17 other campuses are located in Russian provinces and 5 campuses are located abroad. Total number of students is over 53,5 thousand, including 22 thousand in Moscow. Being one of the largest economic institutions in Russia, PRUE considers accreditation as one of the most valuable tools in its efforts to improve quality and competitiveness of education. There are three types of accreditation according to Russian Law on Education: state, public, and professional. Providers of the two last types can be foreign or international organizations (companies, agencies, associations, etc.).

Two important external factors have been forcing leading Russian universities (about 50 out of total 650+ higher educational institutions) to obtain different international accreditations: academic excellence project "5-100" since 2012 and national project "Export of education" since 2017. Both initiatives require significant improvement of quality of education and research, which is expected to increase share of Russia at the international market of education. Government of Russia decided that quality of the education should meet international standards, even if they are somewhat different from traditional Russian requirements. Main reason for such difference is historical separation of research and teaching functions since Russian Academy of Science was founded in 1725. Since then the Academy and its institutions have conducted most of the research while educational institutions has been concentrated on teaching as their primary activity. It inevitably affected quality of education and decreased the scope and the number of research (and publications) originated from Russian universities.

In 2013, PRUE adopted internationalization concept as a part of its strategic development statement. This concept considered international accreditations as a primary tool for quality development for each faculty (institution) and the whole university. Based on negative experience of EFMD (EPAS) accreditation attempt in 2011, concept suggested that at the first stage (2013-2018), most of the faculties should obtain at least one international accreditation for its BSc or MSc programs, and the university at the same time should strengthen its internationalization efforts by attracting more Russian-speaking foreign students and English-speaking teachers and researchers. Second stage (2018-2021) should include moderate growth in international rankings (with higher pace of growth in international faculty share and international students share criteria) and new application for EFMD (EPAS) accreditation.

It was considered that PRUE should extend the number of BSc and MSc programs accredited by international organization so that accreditation process experience for different subject fields (economics, management, marketing, finance, equity, commerce, innovation, etc.) can be obtained. Professional short-term programs of the university also should undergo accreditation procedure by professional foreign associations.

Big Data analysis has emerged as one of the features that add value to academic programs in social and humanitarian sciences both from content and organizational dimensions. Partnership with the following institutions has been established: Central Economic and Mathematical Institute of the Russian Academy of Science, Institute of System Programming of the Russian Academy of Science, and Joint Institute for Nuclear Research.

It permitted to develop new courses to BSc and MSc programs, such as Analytics of Big Data, Modern Programming and Methods of Statistical Analysis, Semantic Research, Forecasting the Dynamics of Macroeconomic and Financial Markets, etc. Also new courses were added to the curriculum of professional (non-degree) programs, such as Legal Aspects of Cryptocurrency and Block-chain Projects, Bitcoin Mining, E-Government, etc.

This new direction allows overcoming some weaknesses mentioned in EFMD (EPAS) peer review report of 2011 on program quality, such as "low level of transfer of current research ideas into the teaching of the program", "limited connections between the corporate world and research activities", "unclear

research policy and relatively low quality of research publications".

Internationalization strategy linked with Big Data and other digital directions allowed PRUE in 5 years to increase number of accredited programs at European Council for Business Education from 2 to 13, as well as obtain accreditations from Chartered Institute of Marketing (CIM), Chartered Institute of Management Accountants (CIMA), The Association of Chartered Certified Accountants (ACCA). In addition, accreditation from Association of MBA's (AMBA) was extended from MBA programs to MSc programs. Consequently, internationalization, inspired by international accreditation, allowed PRUE to increase percentage of international students from 3% in 2013 to 7,4% in 2018 and percentage of international students from 0,5% in 2013 to 5,2% in 2018.

In 2017 as a way to improve quality of education and a tool of quality assurance for potential EFMD (EPAS) accreditation PRUE stated to use individual exam score analysis of almost 50% of the students for more than 70 disciplines with 4-6 intended learning outcomes and consisting of 12-18 topics each.

To make sure that current and prospective curricula are up-to-date with labour market requirements, PRUE administration requested to develop a system for automated analysis of open data from web-based sources, in particular, data placed on various Internet portals (for example, integrator portal of employment agencies) and in social networks (for example, popular Russian social network VKontakte).

After two years a system has been created for monitoring and analysing the staffing requirements of the labour market for university graduates (according to the nomenclature of specialties of Russian higher education). The collection and processing of data in the system is carried out on the basis of modern methods and technologies for obtaining information from web-oriented sources. At the next stage, machine-learning algorithms are used to translate words into a vector representation. Then, offer vectors are calculated, which makes it possible to identify the semantic similarity of the labour market requirements and professional competencies of higher education, which are nothing but short text fragments. The results are used to identify relationships at different levels of models that describe labour markets and higher education. The data collection algorithm is implemented in the form of periodically launched tasks, each of which performs its part of working with data:

- search for new ads by keywords (job title, employer, region, salary, list of duties, list of requirements), which are specified as parameters and allow to limit the subject area;
- the collection and loading of ads in the database;
- selection of significant areas from the text of job announcements (name of vacancy, region, salary, requirements, duties);
- preparation of texts of labour market requirements for further binding.

This system allows PRUE to eliminate such accreditation weaknesses stated by 2011 EFMD (EPAS) peer review report as "not enough institutional corporate connections for research, pedagogy, job placement" and "limited alumni participation in university curriculum development".

At Plekhanov University administration, plans to extend data analysis to its graduates in terms of their career path, competences required and level of competencies obtained at each stage of their career. Such automated complex is intended to be used for collecting, analysing and visualizing data on current unique job vacancies of the labour market and related data (employer location, professional requirements, wage level, etc.). in different regions of the Russian Federation posted on three major Russian job sites ("Work in Russia", HeadHunter, SuperJob) with the ability to display data in the context of current versions of different national and international directories and classifiers. The system makes it possible to obtain data on the number of vacancies in the dynamics in all specialties and allows university to use this system to assess the real needs of employers in specialists in specific areas and specialties, as required by international accreditations as a proof of quality of education.

As a complimentary service, the system also able to detect all possible connections between companies, including foreign, which turns it into a product with high potential for external commercial use. This resource perhaps, has no analogues on the market and allows potential user to solve the following tasks:

- creation a base of non-resident companies operating in the Russian Federation,
- use of all available open sources of information (company registries, data of tax services, customs, courts, data on leaks of information from offshore companies),
- identification and analysis of links between non-resident companies on the basis of various information (managers, co-owners,

subsidiaries, address, telephone, historical links, similarity of names and company profiles, etc.),

- identification of final beneficiaries of non-resident companies.

Apart from the fact that the information base on non-resident companies, collected together from various sources, is valuable in itself, it also provides a unique opportunity to automate the acquisition of new knowledge, such as connections between companies registered in various jurisdictions of the world.

Both Plekhanov Russian University of Economics and HAN University of Applied Sciences (Arnhem Business School), the Netherlands, aim at getting international accredited. For larger institutions, the accreditation process involves the collection and processing of terabytes of data. The data is heterogeneous, in content and in the way it is captured and stored. There is unstructured data like emails and teacher notes; structured data like forms, surveys, and policies, and multimedia like e-Learning modules and recorded class sessions. Presently, the tasks for collecting evidence to verify if a program complies with the requirement of an accreditation body are done manually. Moreover, some data is in digital format while the rest are not. Data is also gathered from different sources like staff, faculty, students and industry through emails, surveys and interviews. The institution then analyses the collected data and publishes a self-study report, which is reviewed by the accreditation body.

Looking at the amount of documents that accreditation institutions are asking, it could be overwhelming for administrators to get them in place and on time. It is clear that providing many of the required documents of the various accreditation institutions can be made much easier and comprehensive when big data technologies are properly used. For example, the criteria of quality assurance is more attainable because of such technologies. This is exemplified by the use of Evalytics at HAN and the automated analysis system developed at PRUE. Since trends in Big Data are not coming to a halt, such technologies will no doubt only become increasingly relevant in the future.

4 CONCLUSIONS AND FURTHER RESEARCH

Data generated at higher educational institutions satisfy the characteristics of Big Data. A university operates various IT systems, such as course management, human resource, student registration, finance and institutional research. These systems generate massive data every semester. Apart from the structured data from the IT systems, students, staff and faculty generate unstructured and semi-structured data, such as Internet traffic, online and offline activities and data emitted from sensors (Gubbi et al., 2013).

Therefore, analysing data from higher-education institutions, based on Big Data methods, is more appropriate than traditional methods. Big Data and data analytics allow researchers and industry to analyse huge datasets and extract valuable patterns (Reed and Dongarra, 2015).

While big data technologies have much potential to them, it remains important to keep researching what the effects are of utilizing these technologies on the performance of students, instructors, and the effectiveness of curriculum development. It would be especially interesting to see how this increases the likelihood of acquiring accreditation. Considering that, the adoption of such technologies is not likely to slow down anytime soon; this might transform the way that education is offered and developed, and how education research is performed.

Currently, the accreditation process works by verifying the self-study report of universities and compare it to evidence found by on-site visits. There could be large discrepancies between the report and the findings. By using different analytic tools to analyse data and provide evidence to check if a specific program matches the expectation of a particular accreditation body prior to the onsite visit

REFERENCES

Ahmed, A.I., 2016. Big Data for Accreditation: A Case Study of Saudi Universities, *Journal of Theoretical and Applied Information Technology*, 91(1)

Arkorful, V. and Abaidoo, N., 2015. The role of e-learning, advantages and disadvantages of its adoption in higher education. *International Journal of Instructional Technology and Distance Learning*, 12(1), p29-42.

Avella, J. T., Kebritchi, M., Nunn, S. G. and Kanai, T., 2016. Learning Analytics Methods, Benefits, and Challenges in Higher Education: A Systematic Literature Review. *Online Learning*, 20(2), p13-29.

Balogh, Z., Munk, M. and Turcani, M., 2013, October. Assessment tools and techniques for e-learning evaluation: Usage analysis and survey sampling. In *Science and Information Conference (SAI),* 2013, (pp. 38-44). IEEE.

Belcadhi, L. C., 2016. Personalized feedback for self-assessment in lifelong learning environments based on

semantic web. *Computers in Human Behavior*, 55, p562–570. https://doi.org/10.1016/j.chb.2015.07.042

Daniel, B.K. and Butson, R., 2013. Technology enhanced analytics (TEA) in higher education. In *Proceedings of the International Conference on Educational Technologies*, 29, p89-96.

Deepa, A. and Chandra Blessie, E., 2017. Big Data Analytics for Accreditation in the Higher Education Sector. *International Journal of Computer Science and Information Technologies*, 8(3), p357-360.

Dunham, I. M., 2014. Big Data: A Revolution That Will Transform How We Live, Work, and Think. *International Journal of Advertising*, 33(1), 181–183. https://doi.org/10.2501/IJA-33-1-181-183

EheFMD., 2018a. Process Manual. Available at: https://efmdglobal.org/wp-content/uploads/EFMD_Global-Accrediation_EPAS-Process_Manual.pdf

EFMD., 2018b. Standards and Criteria. Available at: https://efmdglobal.org/wp-content/uploads/EFMD_Global-Accrediation_EPAS-Standards_and_Criteria.pdf.

Egron-Polak, E. and Hudson, R. 2014. Internationalization of higher education: Growing expectations, essential values. *IAU 4rd Global Survey Report ed*., Paris: International Association of Universities.

Gubbi, J., Buyya, R., Marusic, S. and Palaniswami, M., 2013. Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(7), 1645-1660.

Hughes, G. and Dobbins, C., 2015. The utilization of data analysis techniques in predicting student performance in massive open online courses (MOOCs). *Research and Practice in Technology Enhanced Learning*, 10(1), p1-18.

Koutropoulos, A., Abajian, S. C., Hogue, R. J., Keskin, N. O. and Rodriguez, C. O., 2014. What tweets tell us about MOOC participation. *International Journal of Emerging Technologies in Learning (iJET),* 9(1), p8-21.

Iskandaryan, R., 2018. International accreditations as a tool of university competitiveness improvement. XXXI International Plekhanov Readings. *Theses of PhD students in foreign languages*, p 52-56.

Kellen, V., 2013. Applying Big Data in higher education: A case study. *Cutter Consortium white paper*, 13(8).

McCusker, K. A., Harkin, J., Wilson, S. and Callaghan, M., 2013. Intelligent assessment and content personalisation in adaptive educational systems. In *Information Technology Based Higher Education and Training (ITHET),* 2013 International Conference on (pp. 1-7). IEEE.

Nghe, N. T., Janecek, P. and Haddawy, P., 2007, October. A comparative analysis of techniques for predicting academic performance. In *Frontiers in Education Conference-Global Engineering: Knowledge Without Borders, Opportunities Without Passports,* 2007. FIE'07. 37th Annual (pp. T2G-7). IEEE.

Picciano, A., 2014. Big Data and Learning Analytics in Blended Learning Environments: Benefits and Concerns. *International Journal of Interactive Multimedia and Artificial Intelligence*, 2(7), p35-43. https://doi.org/10.9781/ijimai.2014.275

Porter, W. W., Graham, C. R., Spring, K. A. and Welch, K. R., 2014. Blended learning in higher education: Institutional adoption and implementation. *Computers and Education*, 75, p185–195. https://doi.org/10.1016/j.compedu.2014.02.011

Reed, D.A. and Dongarra, J., 2015. Exascale computing and big data. *Communications of the ACM*, 58(7), p56-68.

Reyes, J. A., 2015. *The skinny on big data in education: Learning analytics simplified. TechTrends*, 59(2), p75–80. https://doi.org/10.1007/s11528-015-0842-1

Romero, C. and Ventura, S., 2010. Educational data mining: a review of the state of the art. *IEEE Transactions on Systems, Man, and Cybernetics, Part C (Applications and Reviews),* 40(6), p601-618.

Shahiri, A. M. and Husain, W., 2015. A review on predicting student's performance using data mining techniques. *Procedia Computer Science*, 72, p414-422.

Steiner, C. M., Kickmeier-Rust, M. D. and Albert, D., 2014. Learning analytics and educational data mining: An overview of recent techniques. *Learning analytics for and in serious games,* 6, p61-75.

Wagner, E. and Ice, P., 2012. Data changes everything. Delivering on the promise of learning analytics. In *higher education. Educause Review*, 47(4), p33-42.

Wen, M., Yang, D., and Rose, C., 2014, July. Sentiment Analysis in MOOC Discussion Forums: What does it tell us? In *Educational data mining*.

West, D. M., 2012. Big data for education: Data mining, data analytics, and web dashboards. *Governance studies at Brookings*, 4(1).

Wolbring, T. and Treischl, E., 2016. Selection bias in students' evaluation of teaching. *Research in higher education*, 57(1), p51-71.