A Novel Design of the Pre-Processing Stage of Data Mining for Educational Purposes

Andreas AHRENS
Hochschule Wismar, Wismar, Germany
andreas.ahrens@hs-wismar.de

Norbert GRÜNWALD
Hochschule Wismar, Wismar, Germany
norbert.gruenwald@hs-wismar.de

Jeļena ZAŠČERINSKA
Centre for Education and Innovation Research, Riga, Latvia
iizi.info@inbox.lv

Julija MELNIKOVA
Klaipeda University, Klaipeda, Lithuania
Julija.melnikova@ku.lt

ABSTRACT

As data sets, in education too, change in size and structure, an appropriate design of the pre-processing stage of data mining for the implementation of data mining for educational purposes is becoming a hot research topic. The aim of the present research is to carry out interdisciplinary analysis of scientific literature on pre-processing in data mining and to design a pre-processing stage of data mining for educational purposes underpinning elaboration of a new research question. The present research employs both theoretical and empirical methods. Theoretical methods include analysis of scientific literature and theoretical modelling. The theoretical findings allow identifying sub-stages of the pre-processing stage for the implementation of data mining for educational purposes. The empirical study was carried out in 2018. The study was a case study. The empirical results emphasize the main areas of analysis of teachers’ behaviour in an international project. The empirical study validates the model of the pre-processing stage of data mining for educational purposes. The practical application of the model allows drawing a conclusion that the model is valid. The novel contribution of this paper is the design of the sub-stages of the pre-processing stage for the implementation of data mining techniques for educational purposes.

Keywords: Data mining, pre-processing stage, data set, teacher behaviour, international project, exploratory research, case study.

INTRODUCTION

Educational data mining is a developing research area that assists in decision making for educational purposes as educational data mining has emerged as an independent research area in recent years (Baker, 2010). Educational data mining often differs from the broader data mining literature, in explicitly exploiting the multiple levels of meaningful hierarchy in educational data (Baker, 2010). For example, methods from the psychometrics literature are often integrated with methods from the machine learning and data mining literatures to achieve this goal (Baker, 2010). Implementation of data mining implies the design of the pre-processing stage. However, the pre-
processing stage of data mining for educational purposes has not attracted a lot of research efforts. Further on, quality assurance in education expands the understanding of teachers’ behaviour and changes data sets in size and structure. Hence, an appropriate pre-processing stage for the implementation of data mining for educational purposes has to be designed. The aim of the present research is to validate the designed model of the pre-processing stage of data mining for educational purposes through interdisciplinary (education and data mining) analysis of scientific literature underpinning elaboration of a new research question. The present research employs theoretical and empirical methods. Theoretical methods include analysis of scientific literature and theoretical modelling. A case study has been applied to the empirical study as “case studies [...] are generalizable to theoretical propositions and not to populations or universes. In doing a case study, researcher’s goal will be to generalize theories (analytical generalization) and not to enumerate frequencies (statistical generalization)” (Yin, 2003, 10). The case study has a qualitative design (Kohlbacher, 2005). Moreover, an exploratory type of the case study has been used (Zainal, 2007) in the empirical study as case studies have an important function in generating new research questions, hypotheses and building theory (Kohlbacher, 2005). Exploratory case studies are set to explore any phenomenon in the data, which serves as a point of interest to the researcher (Zainal, 2007). The exploratory methodology proceeds from exploration in Phase 1 through analysis in Phase 2 to generating a new research question in Phase 3 (Melnikova, Zaščerinska, Glonina, 2015). The interpretive paradigm used in the empirical study is characterized by the researcher’s practical interest in the research question (Cohen, Manion, Morrision, 2003). Researcher is the interpreter.

THEORETICAL MODELLING

The proliferation, ubiquity and increasing power of computer technology has dramatically increased data collection, storage, and manipulation ability (Dermino, Fortingo, 2015). As data sets have grown in size and complexity, direct "hands-on" data analysis has increasingly been augmented with indirect, automated data processing (Dermino, Fortingo, 2015). Automated detection has been already aided by other discoveries in computer science, such as neural networks, cluster analysis, genetic algorithms (1950s), decision trees and decision rules (1960s), and support vector machines (1990s) (Dermino, Fortingo, 2015) including data mining techniques. It should be noted that data mining is defined as the process of uncovering hidden patterns in large data sets (Dermino, Fortingo, 2015). In its turn, patterns such as groups of data records (cluster analysis), unusual records (anomaly detection) and dependencies (association rule mining) based on data collection support decision making (Goyal, Vohra, 2012). Consequently, data mining refers to secondary data collection from a diverse source of documents or electronically stored information (Stewart, 2009) as data mining being an area of methods has an extended history going back to exploratory data analysis (Tukey, 1977) and has established methods for determining validity and generalizability (Slater et al., 2016). Data mining is carried out in three stages (Rogalewicz1, Sika, 2016): 1. Pre-processing: proper preparation of data for modelling, especially elimination or minimization of gross errors through dealing with missing values, and removing outliers and unreal values. 2. Main processing: software is mostly used; specific data mining methods are implemented in order to perform the exploration tasks. 3. Post-processing: interpretation of results obtained at the stage of main processing. Different designs of the pre-processing stage in data mining have been proposed:

- pre-processing as data cleaning and preparation to modelling (Faayad et al., 1996);
- pre-processing implies selection (of a data set), data cleaning and preparation to modelling, transformation (converting data for application of a specific method) (Rogalewicz1, Sika, 2016);
- pre-processing proceeds from sampling (Input Data Source, Sampling, Data Partition) through Exploration (Distribution Explorer, Multiplot, Insight, Association, Variable Selection, Link Analysis) to Modification (Data Set Attributes, Transform Variables, Filter Outliers, Replacement, Clustering, SOM/Kohonen, Time Series) (Marban, Mariscal, Segovia, 2009);
- pre-processing consists of problem identification, transformation of raw and inchoate data streams into applicable forms and formats (Berry, Linoff, 1997; Berry, Linoff, 2000).
Analysis of different designs of the pre-processing stage allows the paper’s authors to model four sub-stages of the pre-processing in data mining implementation for educational purposes: 1. Formulation of research question and/or problem for the implementation of data mining. 2. Sampling (selection and size). 3. Selection of data sets. 4. Data preparation (partition, localisation and cleaning). It should be noted that data partition proceeds (Brinkman, 2009) from identification of main functions or main objects to determination of measurable items of main functions or main objects. Depending on teachers’ behaviour, the teacher can formulate each function and/or item (Bartolini, Ahrens, Zaščerinska, 2018). Another issue is order of questions in secondary data collections from a diverse source of documents or electronically stored information: when people answer a question, there is a risk that they might have been influenced by the previous questions in the questionnaire (Brinkman, 2009). The order of the questions can be controlled by maximizing the number of different topic transitions between questions (Brinkman, 2009).

EMPIRICAL STUDY

Validation of the model of four sub-stages of the pre-processing stage in data mining for educational purposes via input parameter values and distributions has been chosen as the most reliable and preferred way to validate a model (Govindarajan, 2014). The model validation was carried out in 2018 within the Nordplus Adult 2018 project entitled “Adult educators' competence training for development of immigrants and asylum seekers' digital entrepreneurship” to be implemented in Estonia, Latvia, Lithuania and Sweden as efficiency of process including international projects remains the key issue in adult education (Ahrens, Zaščerinska, Melnikova, Andreeva, 2018). It should be noted that the terms “teacher”, “adult educator” and “instructor” are used synonymously in scientific literature. Efficient implementation of international projects implies not only effective use of project’s resources such as intellectual property, human workforce, funding, etc. Efficient international project implementation is targeted to increase the project’s impact. Impact is defined as the influence on the decisions (regardless of outcome) that shape people’s lives, communities, governance, the environment, and elsewhere can be defined as having impact (Federation for the Humanities and Social Sciences, 2014). The project impact, in its turn, has to be sustained beyond the project lifetime. Impact of a project in education is often connected with teachers enrolled in in-service training. In order to strengthen the impact and sustainability of an international project in education, teachers have to be properly selected for in-service training. Teachers are the key to the quality assurance in education as teachers assist learners in the improvement of their learning outcomes as well as raise educational standards (William, 2012). For the selection of right teachers, data mining techniques aimed at predicting teachers’ performance or, in other words, behavior are to be employed. Behaviour is the way an individual acts towards people, society or objects (Guez, Allen, 2000). Behaviour is something that a person does that can be observed, measured, and repeated (Bicard, Bicard, the IRIS Center, 2012). When we clearly define behaviour, we specifically describe actions (Bicard, Bicard, the IRIS Center, 2012). Actions and behaviours can be measured through performance dimensions (Berkeley, 2018). Therefore, the term “performance” has to be defined. Analysis of scientific works reveals such a term as “teacher/instructor performance evaluation” (Asanbe, Ososifian, William, 2016; Ola, Pallaniappan, 2013). However, more often the term “teacher evaluation” (William, 2012) is used in scientific literature. In the present research, both terms, namely “teacher/instructor performance evaluation” and “teacher evaluation”, are used synonymously. The overall aim of teacher evaluation is to create a knowledge-rich teaching profession in which teachers develop a research role alongside their teaching role, with teachers engaging more actively with new knowledge, and benefiting from support structures to generate improvement (OECD, 2009). Teachers’ participation in international projects impacts the development of knowledge-based teaching profession. Consequently, teacher evaluation includes such a dimension as teacher participation in international projects. Teacher evaluation performs two main functions (OECD, 2009): the improvement function and the accountability function. The improvement function is centred on performance improvement (initially at the level of the
individual workforce, and ultimately at the level of the institution (Denisi, Pritchard, 2006). The performance improvement also enables teacher’s activities to personalize the educational process in the classroom. Training is often recognised as a key to improved performance (Manasa, Reddy, 2009). The accountability function includes basis for employment decisions (e.g. promotions, career advancement, performance reward, sanctions, etc) (Ola, Pallaniappan, 2013). Additionally, performance evaluation can aid in the formulation of criteria and selection of individuals who are best suited to perform required organizational tasks (Manasa, Reddy, 2009). It can be part of guiding and monitoring employee career development and improvement (Ola, Pallaniappan, 2013), too. Our “performance” definition is of bimodal nature. By bi-modal phenomenon, a phenomenon that obtains or exhibits two contrasting modes or forms is meant (Zaščerinska et al., 2014). On the one side, our “performance” definition is based on the term „linguistic performance“ used by Noam Chomsky in 1960 to describe "the actual use of language in concrete situations" (Chomsky, 2005). In these terms, performance means the act as the whole. On the other hand, performance is a set of individual activity (Winston et al., 2014). In these terms, performance is a set of activities. By teacher performance, teacher’s individual combination of his/her actual use of professional knowledge in concrete situations as well as a set of his/her professional activities is meant. It should be noted that the development of such a system as cooperative self-adapting Activity Recognition (AR) (Jahn et al., 2018) applied to run-time teacher evaluation will change the scenario of teacher evaluation as well as the landscape of teaching profession. Cooperation of Activity Recognition (AR) systems will take place at several levels of an Activity Recognition (AR) chain (Jahn et al., 2018): at the level of recognised motion primitives (e.g. arm movement) over the level of detected low level activities (e.g. writing) to the level of identified high-level activities (e.g. participating in a meeting or activities of daily living). Performance evaluation is defined as a systematic process of evaluating an individual worker’s job performance and effectiveness in relation to certain pre-established criteria and organizational objectives (Abu-Doleh, Weir, 2007; Mardikyan, Badur, 2011). According to Nakpodia (Nakpodia, 2011), evaluation is an intervention strategy that has received significant attention in academic, business and political circles for information gathering process, ascertaining the decision to be made, selecting related information, collecting and analysing information in order to report summary data useful to decision makers in selecting among alternatives. Currently proper evaluation of teachers’ performance is built on the establishment of reference standards and criteria (OECD, 2009). The main reference standard for teachers’ evaluation typically is their academic and professional qualifications (i.e level of education, experience, certification and licensure) (Goe, Bell, Little, 2008). The key element and fundamental precondition of these must be clearly and concisely stated to know what is expected from teachers at different levels (Goe, Bell, Little, 2008). Instructors’ profiles often express levels of performance appropriate to beginning teachers, experienced teachers, and those with higher responsibilities (Goe, Bell, Little, 2008). It is important to note that professional profiles provide the common basis to organize the key elements of the teaching profession such as initial teacher education, teacher certification, teachers’ ongoing professional development and career advancement (Goe, Bell, Little, 2008). These four key elements of the teaching profession also serve as performance dimensions for analysis of teacher behaviour (Goe, Bell, Little, 2008). Another essential basis for good practice in evaluation is the existence of clear and measurable criteria which must be consistently applied by competent (trained and experienced) evaluators (Drake, 1984; TDA, 2007). This requires the development of explicit guidelines about what is expected from professional practice (Ola, Pallaniappan, 2013). UNESCO’s analysis of the European and Latin American teacher education system emphasizes the content knowledge, the pedagogical skills, the abilities to assess instructors and the professional responsibilities vis-à-vis the school and the students as key domains to evaluate teachers (Ola, Pallaniappan, 2013). However, the analysis does not include the engagement in professional development as a common teaching standard in European systems, with a subsequent risk to undervalue the teacher’s engagement and willingness to enhance his or her own practice (Ola, Pallaniappan, 2013). The present part of the paper demonstrates the application of the four sub-stages of the pre-processing designed within the present research. The first sub-stage of the pre-processing includes formulation of research question and/or problem for the implementation of
data mining for educational purposes. For problem identification, the tasks of the Nordplus Adult 2018 project are analysed. The Nordplus Adult 2018 project aims to carry out pilot implementation of training programme for adult educators and to assess its effectiveness. Training programme is to be delivered during 3 days. The organisers of the training programme intend to invite target group representatives (adult educators especially those who work with immigrants and asylum seekers). During the pilot implementation not less than 30 adult educators from different institutions (working with immigrants and asylum seekers in Lithuania) will take part. The project partners may invite representatives of the target group from their countries (Estonia, Latvia and Sweden), too. Evaluation of adult educators is carried out by the project management only. Consequently, the problem is selection of teachers for the training programme. As data mining assists in uncovering hidden patterns in large data sets (Dermino, Fortingo, 2015), the research question is as follows: What are proper teachers for the training programme?

Table 1: Performance dimensions’ design for analysis of adult educators’ behaviour within an international project

| Main area                                      | Sub-area                                      | Level                  |
|------------------------------------------------|-----------------------------------------------|------------------------|
| Personal information                           | Name                                          | Nominal                |
|                                                | Gender (male, female)                         | Nominal, Dichotomous   |
|                                                | Position (teacher, manager, etc)              | Nominal                |
|                                                | Language(s) of course delivery                | Nominal                |
|                                                | Country of origin                             | Nominal                |
| Initial education                              | Initial education (BA, MA, PhD)               | Ordinal                |
| Involvement in digital entrepreneurship         | Entrepreneurship                              | Ordinal                |
|                                                | Digitalisation                               | Ordinal                |
| Teacher education certification                | Teacher education certification (BA, MA, PhD, non-formal education) | Ordinal                |
| Ongoing professional development              | Informal and non-formal education             | Ordinal                |
|                                                | International projects                        | Ordinal                |
|                                                | Publications                                 | Ordinal                |

The second sub-stage of the pre-processing focuses on sampling (selection and size). In educational research, the best procedure for selecting such a sample is to use probability sampling as non-probability sampling does not ensure the construction of a parameter for a population (Ahrens, Zaščerinska, 2014). The sampling size is limited by the adult educators available in the Nordplus Adult 2018 project’s partner countries. The third sub-stage of the pre-processing deals with the selection of data sets. The selection of data sets is also limited by the secondary data collection from diverse sources of documents or electronically stored information available in the Nordplus Adult 2018 project’s partner countries (Estonia, Latvia, Lithuania and Sweden). The fourth sub-stage of the pre-processing serves as data preparation (partition and cleaning). As discussed before data partition proceeds from identification of main functions or main objects to determination of measurable items of main functions or main objects (Brinkman, 2009). The Nordplus Adult 2018 project is focused on three main areas such as adult education, immigrants and asylum seekers’ and digital entrepreneurship. These key areas of the Nordplus Adult 2018 project expand the main functions/ main objects/ main areas of the adult educators’ performance dimensions such as initial teacher education, teacher certification, teachers’ ongoing professional development and career.
advancement with language(s) of course delivery and country of origin. The main areas of the adult educators’ performance dimensions are extended as plurilingual adult educators with a different country of origin can assist immigrants and asylum seekers in learning digital entrepreneurship in a more efficient way as they obtain and are able to apply their multicultural experience in teaching. The same refers to adult educators’ initial education: some of adult educators before starting their career in adult education studied other areas than education science. This initial education experience can be integrated into their teaching digital entrepreneurship to immigrants and asylum seekers. Table 1 based on the analysis carried out within the present work and by Asanbe, Osofisan, William (2016) presents the performance dimensions for analysis of adult educators’ behaviour. In comparison to the performance dimensions worked out by Asanbe, Osofisan, William (2016), the performance dimensions designed within the present research do not focus on teacher ranking at adult education organisation, teacher appointment status and extension of teaching experience. The authors of the present work consider that for adult educators in order to be selected for in-service training within an international project, teacher educational background, teacher ongoing professional development as well as teacher involvement in digital entrepreneurship are important.

CONCLUSIONS

The theoretical analysis carried out within the present research contributes to the conclusion that teacher participation in international projects is an area/domain of teacher evaluation. The findings of the theoretical investigation of the definitions of „performance“ allow defining “performance” as a bimodal phenomenon. The analysis of scientific literature results in the model of four sub-stages of the pre-processing of data mining for educational purposes. The findings on data preparation for analysis of teachers’ behaviour allow determining the dimensions as well as main areas of teachers’ performance within an international project. The practical application of the model allows drawing a conclusion that the model is valid. The present research has limitations. Theoretical basis of the pre-processing stage of data mining is based on the inter-connections between data mining and stages of data mining. The bi-modal definition of „performance“ has been set. Another limitation is that the model of the pre-processing of data mining for educational purposes is validated only within one international project. Therefore, results of the study cannot be representative for the whole education area. Nevertheless, results of the research – four sub-stages of the pre-processing in data mining and performance dimensions of teachers’ behaviour within an international project - may be used as a basis for analysis of teachers’ behaviour through the implementation of data mining techniques in large datasets. The following research question has been formulated: What data mining techniques support decision makers in selecting proper teachers for the training programme within an international project? Further research intends to focus on implementation of data mining techniques to support decision makers in selecting proper teachers for the training programme within an international project. Future work will imply validation of the designed model of four sub-stages of the pre-processing in data mining for educational purposes via expert evaluation. Comparative analysis of the pre-processing stages in data mining for educational purposes could be also carried out. Investigation of inter-relationships between efficiency of teacher participation in teacher in-service training as well as teacher ranking at adult education organization, his/her appointment status and extension of teaching experience could be interesting for the scientific community. Investigation and gradual incorporation of Activity Recognition (AR) into run-time teacher evaluation would be of a great research interest, too.
REFERENCES

Abu-Doleh J., & Weir D. (2007). Dimensions of Performance Appraisal Systems in Jordanian Private and Public Organizations. International Journal of Human Resource Management, 18(1), 75-84.

Ahrens A., & Zaščerinska J. (2014). Factors that Influence Sample Size in Educational Research. 2014 ATEE Spring University proceedings Changing Education in a Changing Society, pp. 19-32. Klaipeda: Klaipeda University. ISSN 1822-2196.

Ahrens A., Zaščerinska J., Melnikova J., & Andreeva N. (2018). An Innovative Method for Data Mining in Higher Education. Rural Environment. Education. Personality (REEP). Proceedings of the International Scientific Conference, Volume 11, pp. 17-24, 11th - 12th May 2018. Jelgava: Latvia University of Life Sciences and Technologies. Institute of Education and Home Economics.

Asanbe MO., Osofisan AO., & William W.F. (2016). Teachers’ Performance Evaluation in Higher Educational Institution using Data Mining Technique. International Journal of Applied Information Systems (IJAIS), 10(7). New York: Foundation of Computer Science FCS.

Baker, R.S.J.d. (2010). Data Mining for Education. To appear in McGaw, B., Peterson, P., Baker, E. (Eds.) International Encyclopedia of Education (3rd edition). Oxford, UK: Elsevier.

Bartolini, DN., Ahrens &, A., Zaščerinska, J. (2018). Instrument Design for Cyber Risk Assessment in Insurability Verification. 8th International Interdisciplinary PhD Workshop/ 12PhDW 2018 Conference Proceedings (USB), 9-12 May 2018, Swinoujscie, Poland.

Berkeley H. (2018). Guide to Managing Human Resources. University of California.

Berry M.J.A., & Linoff G. (1997). Data mining techniques: for marketing, sales, and customer support. Wiley & Sons.

Berry M.J.A., & Linoff G. (2000). Mastering data mining. Wiley & Sons.

Bicard S. C, Bicard D. F., & the IRIS Center. (2012). Defining behaviour. Retrieved March 25, 2019, from http://iris.peabody.vanderbilt.edu/wp-content/uploads/pdf_case_studies/ics_defbeh.pdf.

Brinkman W.-P. (2009). Design of a Questionnaire Instrument. Handbook of Mobile Technology Research Methods, pp. 31-57, Nova Publisher. ISBN 978-1-60692-767-0.

Chomsky N. (2006). Language and Mind Third Edition. Cambridge University Press.

Cohen L., Manion L., & Morrision K. (2003). Research Methods in Education. London and New York: Routledge/Falmer Taylor & Francis Group.

Denisi A., & Pritchard R. (2006). Performance Appraisal, Performance Management, and improving individual performance: A motivational framework. Management and Organization Review, 2(2), 253-277.

Dermino F., & Fortingo K. (2015). What is Data Mining Methods with Different Group of Clustering and Classification. American Journal of Mobile Systems, Applications and Services. Vol. 1, No. 2, 2015, pp. 140-151 http://www.aiscience.org/journal/ajmsas
Drake, JM. (1984). Improving Teacher Performance through Evaluation and Supervision. Paper presented at the annual meeting of the National Association of Secondary School Principals, February 1984. ED 250 782, 1984.

Faayad U.M., Piatetsky-Shapiro G., Smyth P., & Uthurusamy R. (1996). Advances in knowledge discovering and data mining. American Association for Artificial Intelligence, 1996.

Federation for the Humanities and Social Sciences (2014). The Impacts of Humanities and Social Science Research. Working Paper. October 2014.

Goe L., Bell C., & Little O. (2008). Approaches to Evaluating Teacher Effectiveness: A Research Synthesis. June 2008. National Comprehensive Center for Teacher Quality, sponsored under government cooperative agreement number S283B050051.

Govindarajan, M. (2014). Decision Making Methods. In John Wang, Encyclopedia of Business Analytics and Optimization. IGI Global.

Goyal M., & Vohra R. (2012). Applications of Data Mining in Higher Education. IJCSI International Journal of Computer Science Issues, Vol. 9, Issue 2, No 1, March 2012.

Guez, W., & Allen, J. (2000). Behaviour Modification, Regional Training Seminar on Guidance and Counselling Module 4. France: UNESCO.

Jahn A., Tomforde S., Morold M., David K., & Sick B. (2018). Towards Cooperative Self-adapting Activity Recognition. Proceedings of the 8th International Joint Conference on Pervasive and Embedded Computing and Communication Systems (PECCS 2018), pages 77-84.

Kohlbacher, F. (2005). The Use of Qualitative Content Analysis in Case Study Research. Forum: Qualitative Social Research, Vol. 7(1), Art. 21.

Manasa K., & Reddy N. (2009). Role of Training in Improving Performance. The IUP Journal of Soft Skills, 3, 72-80, 2009.

Marban O., Mariscal G., & Segovia J. (2009). A Data Mining & Knowledge Discovery Process Model. Dat. Min. and Know. Disc. Proc., INTECH Open Science, 2009.

Mardikyan S., & Badur B. (2011). Analyzing Teaching Performance of Instructors Using Data Mining Techniques”, in Journal of Informatics in Education, 2011, Vol. 10, No. 2, 245–257 245.

Melnikova J., Zaščerinska J., & Glonina O. (2015). A Conceptual Framework on Entrepreneurship Education in Vocational Teachers Training. The proceedings of 10th International Young Scientist Conference, pp. 60-69. Riga: Riga Teacher Training and Educational Management Academy, 137 p.

Nakpodia ED. (2011). A Critique of the Methods of Evaluating the Competency of Lecturers in Nigerian Tertiary Institutions, African Journal of Education and Technology, 1(1), 2011, 53-59.

Ola AF., & Pallaniappan S. (2013). A data mining model for evaluation of instructors’ performance in higher institutions of learning using machine learning algorithms. International Journal of Conceptions on Computing and Information Technology Vol. 1, Issue 2, Dec’ 2013.

Organisation for Economic Co-operation and Development (OECD). (2009). Teacher Evaluation: A Conceptual Framework and Examples of Country Practices. A paper was presented at the OECD-
Mexico Workshop Towards a Teacher Evaluation Framework in Mexico: International Practices, Criteria and Mechanisms, held in Mexico City on 1-2 December 2009.

Phillips D. (2006). Comparative Education: method. Research in Comparative and International Education, Volume 1, Number 4, 2006, 304-319.

Rogalewicz M., & Sika R. (2016). Methodologies of Knowledge Discovery from Data and Data Mining Methods in Mechanical Engineering. Management and Production Engineering Review. Volume 7 • Number 4 • December 2016 • pp. 97–108. DOI: 10.1515/mper-2016-0040.

Slater S., Joksimovic S., Kovanovic V., Baker R.S., & Gasevic D. (2016). Tools for educational data mining: a review. Journal of Educational and Behavioural Statistics.

Stewart. A.M., (2009). A Research Guide for Students and Teachers. State University of New York College of Environmental Science and Forestry.

Taylor P., & Medina M. (2013). Educational Research Paradigms: From Positivism to Multiparadigmatic. Journal of Meaning Centred Education. 1 (1), 2013.

Training and Development Agency (TDA) for Schools (2007). Professional Standards for Teachers: Why Sit Still in Your Career? TDA, United Kingdom.

Tukey J. W. (1977). Exploratory data analysis. Reading, PA: Addison-Wesley.

William, JM. (2012). Research-Based Options for Education Policymaking - Teacher Evaluation. National Education Policy Centre (NEPC).

Winston B., Charles E., Lance D., & Woehr J. (2014). Performance Measurement: Current Perspectives and Future Challenges. Psychology Press. pp. 115–116. ISBN 978-1-317-82454-1.

Yin, R.K. (2003). Case study research, design and methods. 3rd ed., Vol.5. Thousand Oaks: Sage.

Zainal, Z. (2007). Case Study as a Research Method. Jurnal Kemanusiaan bil. 9.

Zaščerinska J., Aļeksejeva L., Andreeva N., & Zaščerinskis M. (2014). Bi-Modal Nature of Languaging”. Electronic Journal Thought Elaboration: Linguistics, Literature, Media Expression: TELL ME 2013, 114-126, Vilnius: Vilnius University.