Data Analysis Competencies in Professional Standards: From Data-Experts to Evidence-based Education

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Abstract. The paper discloses the methodology of training specialists in evidence-based education development, competent in analyzing educational data. The ways of institutionalizing the methodological principles of professional development of data analysis specialists are considered through educational programs and professional standards. The author characterizes features of educational programs design of higher and additional vocational education to train specialists in the evidence-based development of education. The research problem is related to the emergence of new labor functions of professionals' education in educational practice with the digitalization of education, the accumulation of digital traces of school students, and the development of digital data analytics services. At the same time, there are no specialized programs for professional development. New job functions are not regulated in professional standards, and complementarity in professional development requirements between the national and European qualifications are not established. Consequently, it is necessary to develop a structure of competencies for professional activities of educational data analysis. Further, according to the developed structure and profiles of competencies, it is necessary to develop specialized educational programs for training data-experts in education. The author posed two issues: (1) what is the structure of the competence of data-experts in education; and (2) what is the methodology for designing educational programs for training data-experts. The research result is the development of the structure of data-expert competencies and methodology for training data-experts. The research contribution to science is associated with the development of data science and additional education theory (methodology for training data-experts).

Keywords: Methodology for training professionals in evidence-based education development · Professional standards · Educational standards · Professional competencies · Analysis of educational data · Management of education based on data

1 Introduction

Development in the sixth technological order is associated with the macro

technologies of the digital economy (Glazyev, 1993, 2017; Schumpeter, 1915). The development of the education sector is also associated with technological, humanitarian, and institutional changes.

The development of education cannot be formed within the development and description of new scientific and technological solutions to digitalize education. It must consider the various possibilities of institutionalizing digital solutions, their integration into existing standards, or the development of new norms and standards.

During the implementation of the projects "Methodology for Big Data Analysis in Education and its Integration into Professional Development Programs for Teachers and Educational Leaders in Logic," "Data-Driven Pedagogy," and "Data-Driven Education Management" within the framework of grant No. 19-29-14016 of the Russian Foundation for Fundamental Research, the author develops a methodology and technology for analyzing big data in education (Fiofanova, 2020). To elaborate data analysis professionals, it is necessary to design professional training programs, education management based on data, and develop evidence-based education. To integrate the methodology for analyzing educational data into the practice of professional activities of teachers and educational leaders, it is necessary to introduce the relevant competencies of data analysis into the requirements of professional standards. This will allow institutionalizing the methodology and technologies for analyzing educational data, creating a new cultural norm of professionalism in education management.

We consider the competence of data analysis in professional standards and the features of training professionals in evidence-based education development.

2 Materials and Methods

The research methodology and methods include the following:

- Structural and functional analysis of qualifications frameworks and models of digital competencies for education professionals;
- Analysis of the genesis of labor actions of professionals in the full cycle of management of education development;
- Designing a competency-based model for training professionals in evidence-based education development;
- Assessment of the competence development of professionals, their competencies in the application of data analysis technologies for the evidence-based development of education;
- Institutional analysis of professional practices of educational data analysis and formation based on an analysis of sound management decisions.

Structural and functional analysis of qualifications and models of digital competencies of education professionals revealed that the Digital Competence of Educators [DigCompEdu] model (European Commission, n.d.) is implemented in European countries. This model includes qualification characteristics, structurally and functionally defined in three modules:

1) Digital professional competencies (communication, reflection, and cooperation in the digital environment);
2) Digital pedagogical competencies (designing digital educational resources, organizing a training on digital educational platforms, and analyzing digital footprints and educational data);
3) Digital competencies in the formation of digital proficiency in children (choice of means and technologies for the development of data proficiency in children, consulting on the child's choice of a digital educational trajectory, and expanding development opportunities in the digital environment).

As seen, the characteristics of the professional activity standards are presented in the full cycle of human education management in the digital environment.

The successful implementation of the DigCompEdu model in the standardization and certification of professional activities of education specialists is associated with the development of national data management standards in European countries. The comparative study of O. A. Fiofanova and E. S. Toporkova (2020) shows that:

1) Trends in the implementation of data-driven management policies and the ideology of open data are associated with (1) ensuring the organizational cohesion of institutions that provide educational data through legal regulations and laws of countries, and (2) the development and implementation of integral digital technologies that allow integrating different types of educational data through digital processing programs for building a system of connections and predicting opportunities;
2) Countries implementing a policy of human development through projects of state programs for the development of education organize the collection and analysis of data based on two methodologies. First, a humanitarian methodology, in which the nature of data is associated with human activities (students) – these are digital traces of subjects of educational activities; second – institutional methodology, in which the nature of the data is associated with reports on the conditions of educational activity, and reports on the implementation of educational development programs. Subsequently, these two variables are compared in the search for correlations for evidence-based analytics as a basis for making decisions about evidence-based development of education.

In Russia, the development of methodological principles and technologies for data analysis – methodological standards for modernizing data management systems – began in 2019, connected with the development of the National Data Management System. The National Data Management System implementation involves developing methodological standards for the modernization of educational database management systems, including the analysis of educational data (Educational Data Mining) and for making organizational, pedagogical, and managerial decisions about education and child development.

The legal framework for analyzing the labor actions of education professionals and designing a competency-based model for training professionals in evidence-

based education development is the National Qualifications Framework. The professional standard of the teacher and the draft professional standard of the head of the educational organization require improvement.

It should be noted that even with the developed system of programs for the professional development of competencies in the field of data analysis, the new job function of analyzing educational data, organizing students' education, and evidence-based development of education requires institutionalization through professional standards.

Within the "Methodology for analyzing big data in education and its integration into professional development programs for teachers and educational leaders" research project, changes are proposed to update professional standards to introduce a labor function and actions to analyze educational data, and expand opportunities for human development and evidence-based development education (Ministry of Labor and Social Protection of Russian Federation, 2013, 2019, n.d.).

Based on the developed methodology and technology for analyzing educational data, additional professional programs "Data-Driven Pedagogy" and "Data-Driven Education Management" were developed.

The results of the genesis of labor actions of professionals in the full cycle of education development management analysis revealed that in their labor activities, education professionals use:

- Methods of analysis and interpretation of data to predict individual educational progress (based on the analysis of data on the cognitive abilities of children, inclinations, and abilities that ensure individual educational progress, and results based on the outcomes of subject diagnostics of the quality of knowledge, analysis of data on the relationship between educational achievements of schoolchildren and attendance of additional programs education of children, etc.);
- Methods of analysis and interpretation of data on the cognitive and personal characteristics of children, the peculiarities of the motivational choice of learning profiles for designing the content of electronic educational environments and individual educational routes (based on the analysis of digital traces of school students on the choice of difficulty levels of tasks, education profiles, the choice of topics for design and research work with school students, etc.);
- Methods of analysis and interpretation of data on the quality of education based on the results of the final certification and Olympiad achievements of school students, international studies of the quality of education for the development of organizational and pedagogical decisions, managerial decisions on improving the quality of education for evidence-based educational policy.

These educational data analytics methods form the content of the programs "Data-Driven Pedagogy," "Data-Driven Education Management," and in the design of the expected competence-based results of mastering additional professional programs. This, in turn, creates conditions for the development of mass practice and competencies in the analysis of educational data in the general

education system, the use of digital services to analyze educational data for the development of organizational, pedagogical, and managerial decisions in education.

3 Results

Based on the results of the programs for the professional development of teachers and education leaders "Data-Driven Pedagogy" and "Data-Driven Education Management," a positive dynamic of the development of digital competencies of educational data analysis was revealed (Fig. 1) (the number of participants – 1,245 people).

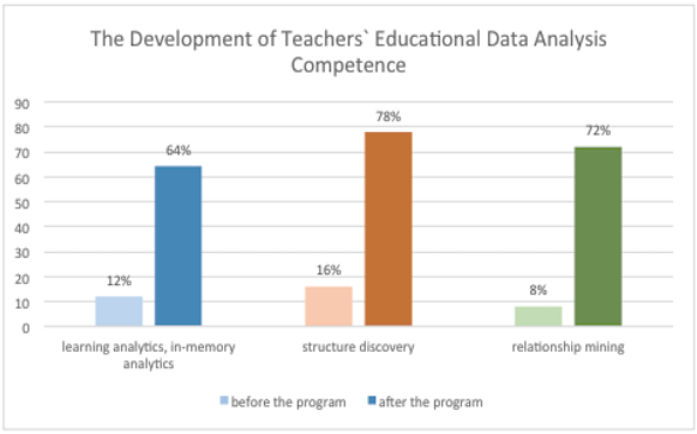

Fig. 1. Development of Teachers Educational Data Analysis Competence. *Source:* Compiled by the author.

The effectiveness of training professionals in the evidence-based development of education is assessed by the positive dynamics of three indicators: the growth of competencies in the application of methods for (1) predicting the value of the quantity of interest, based on the values of educational data predictors; (2) identifying the structure and clustering of educational data; and (3) identifying relationships between variables in a set of educational data.

In fact, these three groups of methods form the basis of professionalism in data-driven education management in the full project cycle.

In terms of the indicator "awareness of digital educational data services," there is also a positive trend (Table 1) among all program participants (number of participants – 1,245 people).

Table 1. Awareness of education professionals about digital services educational data analyst.

Awareness of the types of data analytics services	**Before participating in a professional development program**	**After participating in a professional development program**
Services of data of educational attendance, individual educational progress of students (electronic diary, electronic journal)	85%	100%
Services for analytics of students' digital traces (school, regional, and national electronic educational platforms)	65%	100%
Knowledge quality assessment data services	70%	100%
Olympiad achievements data services	60%	100%
Services of independent assessment of educational organizations	35%	100%
Monitoring data services for education	25%	100%
International Education Quality Research Data Services	30%	100%

Source: Compiled by the author.

Thus, the author concludes that the development of education data analysis competencies is associated with mastering the system of data analytics methods and expanding ideas about the technological infrastructure of educational data analytics – a system of digital data services.

The remaining problem is the development of integration capabilities of electronic services and information systems in education for solving the problems of complex analytics of educational data.

4 Discussion

In Russia, the development of the integration capabilities of electronic services and information systems in education is actualized to solve the problems of complex analytics, the development of infrastructural and technological capabilities for systematizing data from various information systems and electronic services to obtain random samples and slices of information for

organizational, pedagogical, and managerial solutions in education and child development. Such kind of software solutions creates repositories of data on the education and development of students in the developed countries, including integral analytics and statistics of education, data on electronic passports of student competencies, the possibility of converting recorded educational achievements during the transition to the next level of education, the possibility of building-integrated analytics on the development of educational organizations, and the educational conditions they provide and the results of the quality of education.

The problem of the need to develop integrating software solutions and services is related to the following. Data on education and child development is collected by disparate digital systems and is practically not used for integral solutions. For example:

1) According to the indicators of monitoring the education system by order of the Ministry of Education, the heads of educational organizations or the specialists appointed by them fill out the reporting forms: OO-1, OO-2;
2) In the system of regional centers for assessing the quality of education, each teacher works with data on the analytics of the results of diagnosing the educational results of students in subjects;
3) In the data system of the All-Russian Olympiad for school students, through the specialized entrance of the single registration service (SRS) on the Olympiad portal, it can receive data on the educational achievements of the Olympiad level of students (Unified registration system, n.d.);
4) In the system of independent data assessment, it can obtain data on the independent assessment of the quality by consumers of educational services (Quality of Education Moscow Center, n.d. Independent assessment of the quality of services. State municipal institutions. Analytical reports, n.d.);
5) When preparing an annual report on the quality of education by regulating the internal assessment of education quality in a general education organization, the teacher or the head of the organization needs to integrate all data on education and child development themself, analyze the summary data and draw graphs.

Many electronic educational platforms that autonomously collect educational data in the form of digital traces (i.e., uchi.ru, foxford, MES, NES, etc.) also have no integration tasks either horizontally (among themselves) or vertically (with other data analytics systems).

In connection with the development of the technological infrastructure of education, electronic educational platforms, and digital services for educational analytics, the formulation of the problem on the scale and reporting forms should radically change. This is a question of educational data analytics software services and integration capabilities of digital educational data platforms.

The author argues whether it is possible to create an integrated service for generalized data analysis, what organizational strategies and scenarios are possible (standalone or integration), does it have a single entry point (“one student - one computer”), or it is local services with the possibility of integral data uploading on the “generalizing portal,” and what kind of solutions does it need (which technical

solutions and legal regulations).

Currently, integration services for educational data analytics, including digital services for converting educational achievements of schoolchildren, digital services for integrated analytics in education, are developing thanks to customers and strategists of the university (district level), regional level, and the level of stock investors, for example:

1) University "Higher School of Economics" University District, which provides access to data through the school's personal account and implements the conversion of educational results when school graduates enter the university (School authorization on the portal of the University district of the National Research University Higher School of Economics, n.d.; University District of the National Research University Higher School of Economics in Perm, n.d.);
2) Digital platform of Ugra with the function of a digital portfolio, which implements integral analytics of the educational results of school students (Digital educational platform Ugra, n.d.);
3) Equity investments – Sberbank's charitable foundation "Contribution to the Future," which creates the program "Digital platform of personalized education for schools" according to the President's instruction of January 30, 2019 No. 118, Item 1a (Presidential Executive Office, 2019; "Digital Platform for Personalized Education for School" Program, n.d.; Sberbank, 2020);
4) Hackathons for developers of mobile applications and web services based on open data (i.e., "The best social application "Moscow Schools") (Government of Russian Federation, 2019a).

The budget for such a project is formed (1) within the University Development Programs budget (especially relevant for universities of the 5–100 program (Ministry of Science and Higher Education of Russian Federation, 2012); (2) within a special technical assignment for a procurement competition for the execution of state works commissioned by a regional authority in the field of education and, accordingly, the budget of the regional state program for the development of education; (3) public-private investments, including at the expense of part of the funds of the national project "Education."

From the point of technical solutions to the issue of designing the integration capabilities of electronic services and information systems, the following technical solutions are used:

– Revision (corrective, experimental, and design) is aimed at operational changes in software and information support, improvement (i.e., technical tools for collecting educational data through the OO-1 and OO-2 statistical reporting (an earlier version of them) (Forum State Information and Computing Center, n.d.);
– Modification – operational changes in the software: change in operational characteristics without changing functions (i.e., changing the software of the Moscow Electronic School in connection with the development of additional functions and services of the mobile application) (Moscow Electronic School Applications, n.d.);

– Version – a change in the software that is mandatory for transfer to implementation objects, ensuring the transition to new operating systems and information environment (i.e., transition to the State Information System of the Novosibirsk Region "Electronic Diary" or "Electronic Journal" of Electronic School system from the "Dnevnik.ru" system following the Order of the Ministry of the Novosibirsk Region of October 3, 2018 No. 0937-od *On the organization of work in the state information system Electronic school of the Novosibirsk region* (Ministry of Novosibirsk Region, 2018; State Information System of Novosibirsk Region, 2018);
– Development – planned changes to the information system related to the introduction of new functions and improvement of operational characteristics, the transition to a new information environment, the introduction of new complexes of technical means, and new information technologies (i.e., changing the SOCRAT v4.1 software to SOCRAT Personal 5.01 (Systemexplorer, n.d.)) as more optimal software for the implementation of variable education.

Thus, changes in the technological infrastructure of education, the development of integration services for data analytics will lead to a change in the labor actions of education specialists in performing labor functions of analyzing educational data for the evidence-based development of education. This, in turn, will lead to a change in occupational standards in the education sector. It will also contribute to the development of new models of training professionals in evidence-based education development.

5 Conclusion

As a result, the author concludes that the development of education data analysis competencies is associated with mastering the system of data analytics methods and expanding the understanding of the technological infrastructure of educational data analytics – a system of digital data services.

The remaining problem is the development of integration capabilities of electronic services and information systems in education to solve the problems of complex analytics of educational data.

The technological infrastructure of education is heterogeneous and does not have integrated services for data analytics. It complicates human activities due to the insufficient development of software solutions for integrated analytics of educational data. Since customers build e-education on different software systems and digital applications from different software vendors, solving the problem of integrating educational data analytics becomes more complicated. The complexity is also associated with the need to inherit information systems and applications, which causes the "Path Dependence" for a number of reasons.

As a proposed solution, it is possible to develop a single portal with entry points for system participants at various education levels to download and exchange data and obtain analytical and statistical information. After collecting

and systematizing the data, it is possible to identify inter-component groups of indicators and criteria for assessing education, which can be transferred and adapted between the education system levels. With the further development and refinement of the interaction mechanisms between participants in educational relations, it will become possible to build a quality management system for electronic educational platforms and digital services for analyzing educational data.

In the context of the indicated solutions for the modernization of existing systems and software solutions, it is necessary to use technology and analysis of big data, which allows processing large volumes of multi-format data in comparison with the "standard" scenarios, working with rapidly arriving data with a fast update period and large volumes. This requires a software transition to an open system methodology and the use of middleware class software. Conceptually, this kind of approach is presented in the National Standard of the Russian Federation "Information Technologies. Industrial automation systems and their integration. Interoperability" GOST R 55062-2012 (Information Technologies. Industrial automation systems and their integration. Interoperability, 2013).

A standard for electronic educational platforms and digital services for analyzing educational data should be developed in the future, considering the tasks of integrating and converting educational data.

In the context of implementing a national data management system in Russia (Government of Russian Federation, 2019b), the landscape of the technological infrastructure of educational data analytics will change. The organizational principles and technologies of analytical reporting of teachers and educational organizations, regional or municipal education systems will also change in the context of developing a digital analytical platform concept for providing statistical data (Moscow Electronic School Applications, n.d.). New services and digital platforms will be created to ensure data integrity in state information resources (Quality of Education Moscow Center, n.d.). And, in this regard, new programs for the professional development of the competencies of teachers, education leaders, educational politicians in the field of educational data analysis will be in demand – for organizing personalized education of schoolchildren, for evidence-based management of education development, and evidence-based educational policy.

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