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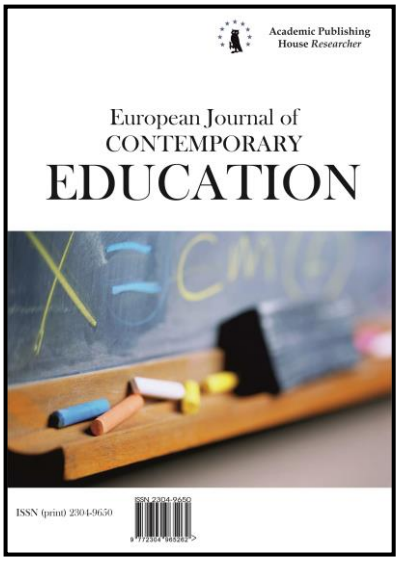

Using Data Analysis Methodology to Foster Professional Competencies in Business Informaticians

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Abstract

This paper addresses the topical issue of searching for optimum technology for fostering professional competencies in a target audience of business informatics students. The authors discuss the relevance of using the competency-based approach in the context of pedagogical goal-setting. The work describes the key stages in a study that involved identifying several areas of activity for business informaticians to focus on in the fields of all-round and deep data analysis and data warehousing. The paper describes the authors' own methodology for helping a student master fundamental algorithms and methods of business analysis. The work shares the findings from the authors' pedagogical experiment on fostering said competencies. The study employed the following methods: analysis, synthesis, formalization, methods of mathematical statistics (Rosenbaum's Q test), and pedagogical experimentation.

Keywords: professional competence, business requirements, business informatics, business analytics, data warehouses, professional competencies, knowledge, abilities, skills, data analysis methodology, pedagogical experiment, methods of mathematical statistics.

1. Introduction

In present-day society, the professional qualities of specialists in various spheres of activity directly depend on their ability to work with information. Special demands are being placed on specialists working in the area of business informatics.

In most economies, there is an increasing social demand for specialists with sufficient knowledge in the areas of information-analytical processing of large volumes of data, unstructured

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information, and software tools. These are the competencies that must be in the arsenal of business informaticians specifically.

Working with decision support systems, artificial intelligence, and intelligent information technology may require studying the characteristics of the actual process of development of professional competencies.

Professional competence is a determinant of successful performance by a specialist, which is based on the volume of their knowledge and abilities and a fusion of their experience and personal qualities, i.e. all the potential that is crucial to achieving high results in their professional activity and being competitive in the labor market (Tret'yakova, 2010).

Competencies have been structured by a number of researchers, who have offered a range of insightful assessments and inferences in respect of the various types thereof, including P.R. Atutov, S.Ya. Botashev, A.P. Belyaeva, V.S. Bezrukova, A.A. Derkach, E.F. Zeer, D. Mertens, L.M. Mitina, and others.

According to J. Raven, competence is a person's capability to perform effectively a specific action within a specific subject domain, which incorporates narrowly specialized knowledge, special subject skills and ways of thinking, and a sense of responsibility for their actions. The researcher views as 'high-level competencies' a strong sense of initiative and organizational skills, required to achieve the goals set, and a readiness to assess and analyze the consequences of one's own actions (Raven, 1984).

V.A. Izvozchikov views the concept of competence as consisting of the following three major aspects: (1) problem-practical (ability to properly articulate and effectively resolve objectives in a given situation), (2) conceptual (ability to properly conceptualize the situation in a more general context), and (3) value-based (ability to properly assess a situation, goals, and objectives from a standpoint of one's own personal and commonly shared values) (Izvozchikov, 1996).

I.A. Zimnyaya construes competence as a person's intellectually and personally conditioned experience of engaging in social-professional activity, which is based on knowledge (Zimnyaya, 2003).

A.V. Khutorskoi views a competency as a set of qualities required in order to work in a certain line of activity. By contrast, the scholar construes competence as a person's "evolved quality (set of qualities) that incorporates a minimum of experience in a certain area" (Khutorskoi, 2005).

E.F. Zeer conceives of competence to be not so much a large amount of knowledge and experience but a person's capability to make actual use of their amassed knowledge and professional abilities where and when necessary in the course of performing their professional duties (Zeer, 2003).

V.V. Serikov construes competence as a "way of existence of knowledge, abilities, and erudition that facilitates the disciple's self-actualization and helps them find their place in this world" (Serikov, 1999).

The competency-based approach is a methodology for designing and organizing the educational process. Along with the transfer of a body of knowledge, abilities, and skills, it helps ensure the student's personal development and foster in them a broad outlook, an interdisciplinary vision of issues, and a capacity for creative work, self-learning, and the learning of common human values. As a necessary condition for preparing a competitive professional in college, the competency-based approach implies making appropriate changes to strategies of pedagogical goal-setting, selection and construction of the content of learning material, organization of educational activity, and planning and assessment of learning outcomes.

A graduate of the Business Informatics program is a specialist who possesses, at a threshold level, interdisciplinary competencies of a business analyst both in the area of development and application of crosscutting digital technology and in the area of organizational design, consulting, and entrepreneurship (Frolov, Sakhnyuk, 2019).

A work by A.V. Demina and A.I. Bezrukov accentuates the need to make use of the project-based approach, which is aimed at fostering in one the competencies needed to work with an organization's IT infrastructure (Demina, Bezrukov, 2019).

Certain researchers have emphasized the need to foster in business informaticians a clear idea of the place and role of information-analytical technology and software tools in resolving professional objectives, help them build a solid knowledge of terminology, and help them master

appropriate systemic scholarly approaches to structuring large arrays of data (Stepanov, Stepanova, 2014).

It has been suggested that a business informatician will not be able to do without competencies in the area of information-analytical support, forecasting, and risk management. A business informatician must have the ability to implement analytical projects and solutions on optimizing an organization's business-processes (Fursov et al., 2015; Knyazev, 2012; Knyazev, 2011).

2. Materials and methods

The aim of this study was to analyze the use of methodologies for working with data in the educational process for the purposes of fostering business analytics competencies in future business informaticians.

Business analytics is a multidisciplinary area that incorporates information technology, databases, intelligent data processing algorithms, mathematical statistics, and business information visualization techniques.

The study consisted of several stages: (1) identifying business informaticians' key lines of activity in the area of data analysis; (2) identifying a set of competencies required to master the latest data analysis technology, which incorporates the theoretical and practical aspects of data warehousing, knowledge discovery in databases, and data mining; (3) determining the content of the knowledge, abilities, and skills required to develop said competencies; (4) putting together a roster of disciplines aimed at developing a certain pool of knowledge, abilities, and skills; (5) identifying algorithms and methods in business analytics that can help foster said competencies; (6) developing a methodology that will help students master relevant business analysis algorithms and techniques; (7) conducting an experiment on fostering said competencies.

The study employed the following methods: analysis, synthesis, formalization, methods of mathematical statistics (Rosenbaum's Q test), and pedagogical experimentation.

The authors' methodology for the use of data analysis technology was tested at the Krasnodar branch of Financial University under the Government of the Russian Federation. To test the methodology, the authors conducted a pedagogical experiment that engaged third-year students majoring in Business Informatics.

In conducting the study, the authors adhered to a plan for their comparative pedagogical experiment, which included the following steps: (1) form two equivalent groups (the experimental and control groups); (2) conduct a pedagogical experiment; (3) conduct a final testing session and a comparison of the results for both groups – the experimental group, which was exposed to pedagogical impact, and the control group, formed to ensure the experiment's purity and assess the outcomes of the impact on the experimental group.

In the first stage of the comparative pedagogical experiment, the authors conducted the selection and leveling of the control and experimental groups. The total study population numbered 90 individuals (N), all of them being third-year students majoring in Business Informatics. The batch consisted of the following four student groups: (1) 301-BI (25 individuals), (2) 302-BI (22), (3) 303-BI (21), and (4) 304-BI (22). Initially, the groups were formed in a random fashion. The average score on disciplines within the information module of the core part of the curriculum was an indicator that determined the homogeneity of groups within the sample. The average score in terms of student progress on disciplines within the information module was as follows: the 301-BI group – 4.04 points; 302-BI – 3.98; 303-BI – 4.1; 302-BI – 4.10. Based on this, it may be assumed that students in the groups had about the same level of knowledge of information disciplines prior to the experiment. Next, the authors drew the experimental sample from the population. The strategy for putting together the sample implied engaging real groups of students to form the experimental and control groups. To form the experimental group, the authors joined two of the student groups. The same was done with the control group. The groups to join were selected in a random fashion. The groups could be joined if they were found to be homogeneous. To test the groups' homogeneity, the authors calculated Student's coefficients. The Student's t-test value for the groups 301-BI and 303-BI was $t = 0.284$. The critical value was $t_{cr} = 2.021$ ($\rho = 0.05$). Consequently, it was possible to join the two groups, as $t < t_{cr}$ ($\rho = 0.05$). The experimental group was made up of students from the groups 301-BI and 304-BI.

The Student's t-test value for the groups 302-BI and 303-BI was $t = 0.1591$. The critical value was $t_{cr} = 2.021$ ($\rho = 0.05$). Consequently, these two groups could be joined, as $t < t_{cr}$. The control

group was made up of students from the groups 302-BI and 303-BI. The size of the experimental group was 47, and that of the control group was 43 individuals.

The groups had to be joined in order to ensure compliance with the requirements of methods of statistical processing, namely Rosenbaum's Q test, whereby the minimum number of respondents must be 11, and the difference in the number of respondents between the samples must be not more than 10.

In terms of the experiment's modifiable conditions, the authors employed interdisciplinary business cases, which were tackled by students in the experimental group, while those in the control group were given traditional assignments.

As a non-modifiable condition for the conduct of the experiment, the authors employed the same theoretical learning material.

To determine the level of one's baseline knowledge of data analysis, the authors tested respondents in both the experimental and control groups. To measure the level of their baseline abilities and skills, the authors gave them practical assignments.

The second stage of the comparative pedagogical experiment involved exposing the experimental group to pedagogical impact using a data analysis methodology, for the purposes of fostering in them a set of professional competencies in business informatics. Those in the control group were given standard assignments in regular disciplines.

The authors' data analysis methodology deals with fostering business informaticians' professional competencies in the area of big data through having them analyze interdisciplinary business cases based on the following three disciplines within the field's module: Business Analysis Information Technology, Business Information Visualization, and Data Analysis.

Before putting together the assignments, it was necessary to determine a set of special competencies needed for working with big data. To identify these competencies, the authors employed the available accumulated experience of solving various business analytical problems.

As a result, the authors identified the following professional big data competencies needed to conduct quality business analysis:

– ability to collect and consolidate data, use data transformation and cleaning algorithms, and apply the practical aspects of data warehousing;

– ability to conduct analysis, put forth hypotheses, and employ the technologies of knowledge discovery in databases and data mining.

To develop the competency dealing with the ability to collect and consolidate data, use data transformation and cleaning algorithms, and apply the practical aspects of data warehousing, a student needs to know the following: basic principles of data analysis, rules for structuring data, and algorithms for preparing data for analysis. Data warehousing implies knowledge of general principles and key concepts in data warehousing and the various types of data warehouses.

The data preprocessing process, required to organize data warehouses, implies fostering knowledge of the various ways to transform data.

An area of working with data such as visualization implies knowledge of the principles and methods used to present data in such a way as to ensure an efficient workflow and knowledge of the various classifications of visualization techniques.

Data cleaning and preprocessing requires knowledge of the concept of 'quality of data', which implies a collection of data's properties and characteristics that determine the degree to which they are suitable for analysis.

To develop the competency dealing with the ability to conduct analysis, put forth hypotheses, and employ the technologies of knowledge discovery in databases and data mining, students must know the basics of association rules theory, methods of implementing association rule search systems, and hierarchical association rules.

Working with data mining requires knowledge of objectives for clustering, clustering algorithms, and problems with clustering algorithms.

Solving classification and regression problems, which are central in data analysis, requires knowledge of methods for actually solving them.

In terms of the first competency, the one dealing with the ability to collect and consolidate data, use data transformation and cleaning algorithms, and apply the practical aspects of data warehousing, it will help to foster in business informatics students a set of abilities related to relational schemas in data warehousing (e.g., Star and Snowflake). To be able to implement hybrid

technology and fuzzy logic, a student needs to have the ability to put together fuzzy slices or fuzzy queries in relational databases.

Retrieving and transferring data into a warehouse implies the use of ETL software. A student majoring in Business Informatics must have the ability to develop a procedure for retrieving data and the ability to transform data to a certain representation, format, or type that is suitable for a task.

Solving data visualization problems as part of the analytical process requires the following abilities: (1) ability to assess the type and behavior of data, the dynamic range of values, the degree of smoothness, and the presence of factors that may affect the quality of data (e.g., noise, missing or anomalous data, etc.); (2) ability to identify techniques for loading data into an analytical application and parameters that need to be used in that context; (3) ability to employ visualization techniques.

When it comes to the second competency, which deals with the ability to conduct analysis, put forth hypotheses, and employ the technologies of knowledge discovery in databases and data mining, students majoring in business informatics will need to develop the ability to work with association rules, technology for retrieving knowledge, clustering, classification, and regression.

In terms of association rules, a student needs to be able to detect associations between various events and describe quantitatively the reciprocal linkages between them.

Implementing knowledge retrieval technology requires formulating association linkages and using algorithms for generating them. More specifically, this will require the ability to compose hierarchical association rules and use methods of searching for hierarchical association rules. Working with association rules in the context of retrieving knowledge from a data warehouse, most importantly, requires the ability to look for and make use of consistent patterns.

To solve the clustering problem in the field of data mining, students majoring in Business Informatics need to have the ability to assess the distance between objects (Euclidean and Manhattan distances).

Two of the most common problems in data mining are classification and regression. Classification requires the ability to build models that describe a predefined set of classes or categories, including regression ones, and put together rules for subsuming an object under a certain class.

The formedness of abilities, as skills honed to perfection, is what characterizes the degree to which the training has been successful and is the next stage in building the required competencies.

In terms of the first competency, which deals with the ability to collect and consolidate data, use data transformation and cleaning algorithms, and apply the practical aspects of data warehousing, students majoring in Business Informatics need to develop the skill of uploading data into a warehouse.

Loading data requires the ability to add new records and alter existing ones. Adding new records requires comparing this information with the one that is in the warehouse.

During the loading process, one may encounter a number of issues, like, for instance, problems caused by blocked loads or wrong load order, and, in some cases, there may be not enough space in the warehouse. The skills of resolving this kind of issues can be developed only through performing the loading of data into a warehouse multiple times.

Post-load operations include re-indexing and verifying data. From a standpoint of a business analyst's competencies, of the greater importance is the skill of solving the verification problem.

To be able to draw conclusions based on the data in the warehouse, a specialist must be confident of both the reliability and completeness of those data. In this respect, of importance is the acquired skill of enriching data.

Solving academic problems will help develop in students the skills of transforming ordered data for forecasting or grouping purposes. To foster the competency dealing with the ability to conduct analysis, put forth hypotheses, and employ the technologies of knowledge discovery in databases and data mining, it will help to develop in students a set of skills that enable solving professional problems that are typically faced by business analysts.

Solving academic problems on business analysis should help a student acquire the skills of applying association rules. Developing further the ability to assess the distance between objects as part of solving the clustering problem in the field of data mining should help foster in business informatics students the skill of selecting a metric for putting together a cluster model.

Developing further the ability to build a model describing a certain set of classes or categories (a training sample) should help foster the skill of forecasting and determining independent variables (predictors) for the purposes of building a classification model.

Solving a regression problem helps foster the skills of assessing the degree to which a simple linear regression model corresponds to real data, determining the correlation coefficient, assessing the significance of a multiple regression model (F-test), selecting variables in a regression model, and interpreting a regression model.

To help develop in students the required knowledge, abilities, and skills via data analysis methodology, the authors identified the following key stages in the learning process: data sampling, data cleaning, data transformation, data mining, and data interpretation.

The first stage deals with data sampling. At this stage, a student gains knowledge of the principles of data warehousing. This knowledge should foster the ability to develop procedures for retrieving and transferring data into a warehouse. Once the step of developing the data retrieval procedure is completed, it becomes possible to foster the skills of loading data into the warehouse from intermediate applications, having in consideration the hierarchy of applications in the procedure. The skill of adding and altering records is linked with comparing new data with the information that is available. Multiple uploads should help foster the skills of resolving problems with the data warehouse interface.

The second stage deals with data cleaning. At this stage, a student gains knowledge of the quality of data. This knowledge helps foster the ability to assess data based on parameters that are crucial to loading data into the warehouse and the skills of identifying methods for loading data into the application and determining the data's parameters. The data cleaning stage involves post-load operations. At this stage, a student develops the key skills of verifying and enriching data in a specific programming environment.

The third stage is associated with data transformation. At this stage, students acquire knowledge of technology for transforming ordered data. Students can develop the ability to design relational data schemas through working with database management systems (DBMS), based on which data warehouses are built. Implemented databases can be used to foster the ability to put together fuzzy queries in relational databases, which are typical in data warehousing. The ability to transform data is developed through working with tables in a relational DBMS. The use of standard SQL queries helps develop the skills of grouping and sorting data, quantization, obtaining the minimum or maximum value in a group, and obtaining other calculated values. Putting together standard reports in working with a relational database will help develop the skills of fine-tuning data.

The fourth stage deals with data mining. At this stage, the student gains knowledge of objectives for clustering, algorithms for clustering and issues associated with them, and methods of classification and regression. This knowledge will help foster the ability to theoretically detect association linkages and describe them quantitatively.

Working with relational databases helps foster the ability to employ algorithms for generating association linkages and utilize consistent templates for searching the data in various subject areas.

A key capability to foster is the practical ability to build association linkages between objects in a relational database, which forms the basis of clustering in data mining.

In parallel with the ability to resolve the clustering problem in working with relational databases, a student develops the ability to classify objects based on the creation of a training sample. After solving the classification data mining problem, it becomes possible to develop the ability to build a regression model and interpret the coefficients of regression to describe the distribution of the values of the objects' attributes.

Solving business problems based on working with a relational database or a relational data warehouse helps a student develop their skills of conducting market basket analysis, generating frequent itemsets using the standard Apriori algorithm, and identifying metrics for the process of formation of classes.

The fifth stage deals with interpretation. At this stage, a student gains knowledge of the principles of how to present data in order to come up with an effective solution to a business problem. It involves fostering the ability to visualize business information, on the one hand, and the ability to perform modeling and forecasting and determine independent variables, on the other.

Knowledge of the basics of visualization of business information helps develop the ability to employ a range of visualization techniques in the context of presenting analytical information. Normally, the skills of visualization are developed in putting together reports in an application. Modeling implies cultivating the skills of evaluating a resulting model using statistical methods.

The knowledge, abilities, and skills that business informatics students could acquire via the authors' data analysis methodology should help develop the competencies needed to work with big data that are sought after at the present stage in the development of IT technology.

To help foster in students a set of relevant competencies in the use of the latest data analysis technology, the authors designed a set of assignments based on resolving real-life business problems. As an analytical platform, the authors employed the Deductor Academic software package.

The authors developed special crosscutting assignments based on resolving real-life business problems (e.g., creation of data warehouses, OLAP, credit scoring, and bulk mailing optimization). A crosscutting assignment is a business case that implies a linkage between a number of disciplines and consists of several blocks that are tackled in a certain sequence. The assignments of the business case employed in this experiment are outlined below.

The students were asked to solve a business problem that was based on a certain situation that had arisen in an organization. One was to identify critical points in the company's business processes and resolve a set of issues facing the executive team in terms of making tactical decisions. To this end, the students were to collect all the missing information, bring forward a solution hypothesis, develop the structure of a data warehouse, fill the warehouse with data, perform a cleaning of the data, prepare the data for further activity dealing with analysis, perform a data analysis based on data mining techniques, and come up with an effective business decision that could help the executive team resolve the issues facing the organization. The students were asked to answer a set of questions that are typically of concern to the executive team, answers to which could influence the company's overall development. These questions may deal with identifying a category of clients who bring the company the greatest profit. Alternatively, an organization may face a problem such as optimizing the operation of its warehouses in terms of handling leftover items. Trading companies may attach relevance to a problem such as the structure of their sales in different periods. Respondents were to provide answers to the questions based on their work across all the technological stages in data analysis prescribed by the methodology.

The third stage in the comparative pedagogical experiment involved assessing the formedness of the knowledge underpinning a student's competencies in the use of the latest data analysis technology through testing. The outcomes of performing the assignments were an indicator of the formedness of the abilities and skills underpinning the competencies.

3. Results

The authors tested their pedagogical methodology by way of a comparative pedagogical experiment.

Using their methodology the authors exposed to pedagogical impact students in the experimental group. Students in the control group performed standard assignments prescribed by the curriculum. The objective was to have developed in one a set of competencies in the area of big data. The level of developed competencies in students in the experimental group was compared with that in students in the control group.

To measure the level of respondents' knowledge, abilities, and skills, the authors employed a 100-point scale.

The results of the experiment were evaluated by way of assignments offered to the students at its start and end. This helped determine the dynamics of the development in students of the required knowledge, abilities, and skills based on the basic, advanced, and high levels of competence.

Students who scored 50 to 65 points were placed in the basic level group, 65 to 85 points – the advanced level group, and 86 to 100 points – the high level group.

The analysis was conducted on all the three categories of competencies (knowledge, abilities, and skills).

As part of the experiment, Business Informatics students in the experimental group (47 individuals) worked on business cases containing crosscutting assignments in the following three disciplines: Business Analysis Information Technology, Business Information Visualization,

and Data Analysis. Business informatics students in the control group (43 individuals) performed standard assignments in regular academic disciplines.

Figure 1 illustrates the actual results of the authors' pedagogical experiment. The histogram reflects the mean values for the experimental and control group through the lens of the components of the competencies under examination (knowledge, abilities, and skills) before and after the experiment.

In the initial stage (prior to the experiment), the mean values for the resulting points in the experimental and control groups did not have significant differences, with these values not reaching the level required for the basic-level grade.

The levels across the categories 'knowledge', 'abilities', and 'skills' were determined based on the points scored. The level of knowledge was determined via special assignments, and that of abilities and skills – via special business problems.

The mean values for the category 'knowledge' were 32 points in the control group and 30 points in the experimental group.

With the category 'abilities', the mean values were 20 points in the control group and 21 points in the experimental group.

With the category 'skills', the mean values were 12 points (the control group) and 14 points (the experimental group).

It may be stated that the knowledge, abilities, and skills acquired by the students previously were not enough for them to be able to answer all the questions and solve all the problems on the business case assignments.

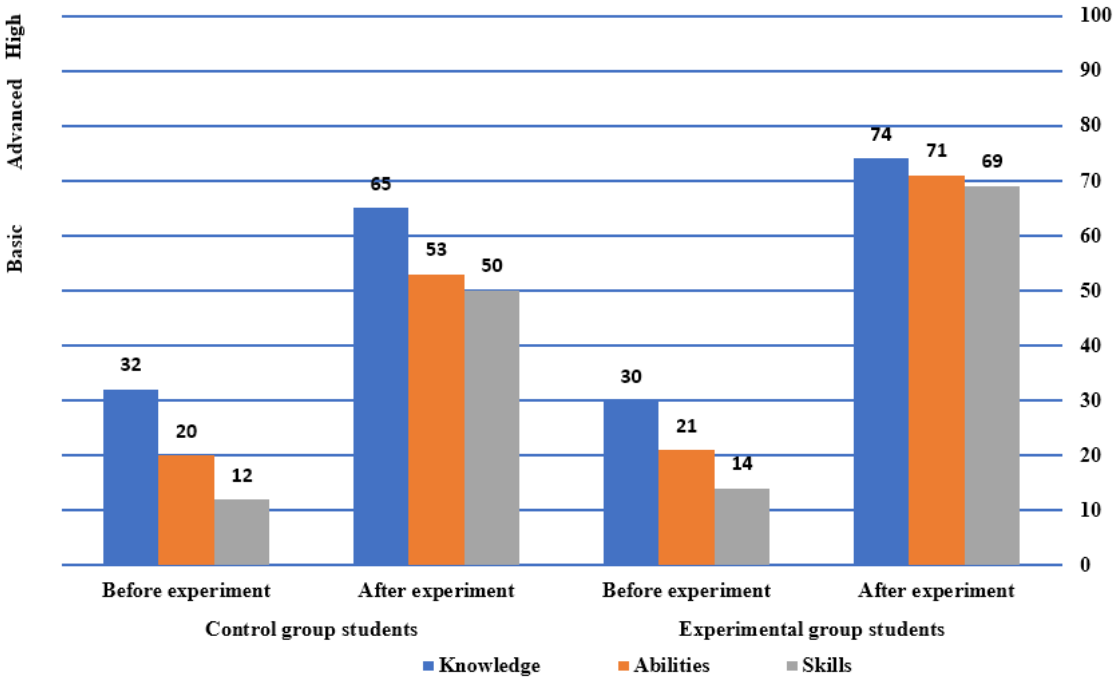

Fig. 1. Histogram detailing the results of the experiment

The mean values of scores had differences after the experiment. The average score on the category 'knowledge' in the control group was 65 points, 'abilities' – 53 points, and 'skills' – 50 points.

Table 1 displays the figures on the formedness of competencies in data analysis in students in the control group. With this group, 48.84 % exhibited a basic level, 46.51 % – an advanced level, and 4.65 % – a high level of competence on the category 'knowledge'.

Table 1. Results in the Final Stage (after the Experiment) in the Control Group

	Knowledge	Abilities	Skills
Did not reach the basic level (less than 50 points)	0 %	6.98 %	6.98 %
Basic level (50 to 65 points)	48.84 %	88.37 %	93.02 %
Advanced level (66 to 84 points)	46.51 %	4.65 %	0.00 %
High level (85 to 100 points)	4.65 %	0.00 %	0.00 %

The results were somewhat poorer on the categories 'abilities and 'skills'. None of the students in the control group was able to reach a high level here, with nearly 7 % unable to reach even a basic level.

With the experimental group, the average score on the category 'knowledge' was 74 points, 'abilities' – 71 points, and 'skills' – 69 points.

Table 2 displays the figures on the formedness of competencies in data analysis in the experimental group. The results demonstrated by this group were higher on all the three categories than those achieved by the control group. There were fewer differences on the category 'knowledge', although the number of those who reached a high level was 12.77 % (with the control group, it was 4.65 %). Among those in the experimental group, 2.13 % demonstrated a high level of abilities, with the figure being 0 % with the control group.

Table 2. Results in the Final Stage (after the Experiment) in the Experimental Group

	Knowledge	Abilities	Skills
Did not reach the basic level (less than 50 points)	0 %	0 %	0 %
Basic level (50 to 65 points)	14.89 %	21.28 %	40.43 %
Advanced level (66 to 84 points)	72.34 %	76.60 %	59.57 %
High level (85 to 100 points)	12.77 %	2.13 %	0.00 %

To test the statistical significance of the differences in the results, the authors employed Rosenbaum's Q test. This method makes it possible to compare the figures in two samples and determine if there are differences between them. The number of subjects must be not less than 11, while the difference in the number of subjects between the samples must be not more than 10 (provided that each group numbers not more than 50 subjects). The authors' experiment met these requirements. The results were compared in the initial and final stages of the experiment.

To test the absence of differences between the resulting values of scores for the control and experimental groups in the initial stage, the authors formulated the hypotheses for each category ('knowledge', 'abilities', and 'skills'):

– hypothesis H_o: the scores achieved by students in the experimental group in the initial stage (prior to the experiment) on the category 'knowledge' (abilities and skills) are not higher than those achieved by students in the control group;

– hypothesis H_1: the scores achieved by students in the experimental group in the initial stage (prior to the experiment) on the category 'knowledge' (abilities and skills) are higher than those achieved by students in the control group.

Having determined the empirical values Q_{emp} for each case, the authors compared the resulting values with the critical values Q_{cr}. Given that the number of students in each group was higher than 26, $Q_{cr} = 8$ ($\rho = 0.05$) and $Q_{cr} = 10$ ($\rho = 0.01$). The resulting empirical values turned to be smaller than the critical ones. For the category 'knowledge' $Q_{emp} = 3$, 'abilities' – $Q_{emp} = 5$, and 'skills' – $Q_{emp} = 2$. Based on this, the authors accepted the hypothesis H_o. Consequently, it may be

concluded that the results obtained in the study's initial stage for the control and experimental groups did not have statistical differences. The groups exhibited a similar level of formedness of knowledge, abilities, and skills in data analysis.

To test the statistical significance of the results in the final stage (after the completion of the experiment), the hypotheses H_0 and H_1 were formulated again:

– hypothesis H_0: the scores achieved by students in the experimental group in the final stage (after the experiment) on the category 'knowledge' (abilities and skills) are not higher than those achieved by students in the control group;

– hypothesis H_1: the scores achieved by students in the experimental group in the final stage (after the experiment) on the category 'knowledge' (abilities and skills) are higher than those achieved by students in the control group.

The authors' calculations helped obtain the empirical value for the category 'knowledge' – $Q_{emp} = 4$. This value was not higher than the critical value even at $\rho = 0.05$, so the hypothesis H_0 was accepted. Based on this, it was concluded that student results on the category 'knowledge' were approximately the same, despite the fact that the average score of students in the experimental group was higher.

The empirical value of the coefficient for the category 'abilities' was $Q_{emp} = 32$. Thus, $Q_{emp} > Q_{cr}$ ($\rho = 0.01$). The authors rejected the hypothesis H_0 and accepted the hypothesis H_1. Based on this, it was concluded that the results of students in the experimental group were higher than those of students in the control group on the category 'abilities'.

The authors compared the empirical value of the coefficient for the category 'skills', which was $Q_{emp} = 36$, with the critical value. On the category 'skills', the conclusion was similar to the previous one – the results of students in the experimental group were higher than those of students in the control group.

4. Discussion

The authors' comparative pedagogical experiment was conducted under real-life conditions of the educational process in a college, having in consideration the distribution of classes in the schedule. The process's real-life conditions imposed some restrictions on the pedagogical experiment. It was impossible to ensure entirely homogenous conditions for the participants. The educational process's conditions predetermined what the population would be in the experiment – 90 third-year students majoring in Business Informatics. The division of students into groups as part of the learning process prevented the authors from making proper use of the probability sampling of subjects method. The strategy for putting together the sample implied engaging real student groups at an educational institution as the experimental and control groups. The authors attempted to neutralize the factors impacting on experiment results through leveling the experimental and control groups in the first stage of the study. As a criterion for leveling, the authors used the average score on disciplines within the information module of the core part of the curriculum.

The experiment has helped contest statements by certain researchers that the present-day Russian system of higher education is characterized by overall negative objective conditions when it comes to the education of students pursuing a Bachelor's degree in Business Informatics. In this context, researchers I.I. Bobrova, I.Yu. Efimova, and E.G. Trofimov have detected a mismatch between expectations set by employers to college graduates, which typically are high, and the actual level of the latter's abilities and skills, which typically is low. The findings from their experiment indicate that the competency-based approach could well be the way to go in the present-day context of the development of education (Bobrova et al., 2018). In the area of ICT, it may help to employ the technique of developing original competencies for particular areas of activity (e.g., data analysis). These competencies could be fostered within the framework of various disciplines. The approach employed with regard to general competencies for the Business Informatics course seems to have run its course. Trends associated with the predominant use of traditional forms of learning and insufficient use of the latest software and communications tools, likewise, could be overcome through properly formulating competencies for particular areas of activity.

The experiment has also helped substantiate the conclusion drawn by certain researchers about the efficiency of the module-based approach in integrating several disciplines in the training of future specialists. In the view of E.A. Barakhsanova and V.A. Varlamova, the technology of

organizing the educational process ought to be based on modular interdisciplinary integration, factoring in the regionalization principle. The researchers appear to be right in their conclusion that in implementing the competency-based, activity-based, and person-oriented approaches it may help to set new requirements for the content of academic disciplines (Barakhsanova, Varlamova, 2015).

Based on the findings from a study by A.S. Kindyashova, the use of problems-based technology to foster subject competencies should facilitate the achievement of productive levels of competence (Kindyashova, 2016). This process augments the use of software tools and the electronic educational environment (Pereira et al., 2018).

The findings from an experiment conducted by E.M. Vorontsova indicate that the process of fostering information competence in students tends to be characterized by positive dynamics, i.e. there are substantial changes in students' knowledge, abilities, and skills of an information nature, which are supported by special didactic training and the use of electronic resources (Vorontsova, 2015).

The latest research on fostering professional competencies in the subject area of working with big data indicates that competency-based didactics makes it possible to employ the IT tools of business analysis and big data to resolve professional problems (Kuzmina et al., 2019).

Based on the findings from a dissertation-based study by O.G. Lysak, the use of educational cluster technology as a tool for self-teaching within the innovation chain 'science – IT tools – business' helps boost the efficiency of the process of fostering professional competencies in undergraduate students (Lysak, 2019).

5. Conclusion

The authors explored some of the key business requirements in the area of business analytics, determined some of the key professional competencies in this subject area, and identified some of the key abilities and skills required to actualize those competencies.

The authors introduced a special data analysis methodology intended to help cultivate said knowledge, abilities, and skills. The methodology involves the following stages: data sampling, data cleaning, data transformation, data mining, and data interpretation. Testing the data analysis methodology helped confirm the authors' conclusion about the efficiency of the competency-based approach in preparing specialists in the IT sphere based on the use of IT technology.

In the experiment's first stage, those in the experimental and control groups did not reach the basic level in terms of their knowledge, abilities, and skills, which figures, as they had just started to study the subject area of data analysis. The results' statistical significance was tested using the non-parametric Rosenbaum's Q test method.

In the final stage, after the completion of the experiment, the authors compared the figures for each category – 'knowledge', 'abilities', and 'skills'. The calculations revealed that this time the figures for the experimental group were significantly higher than those for the control group, with $Q_{emp}>Q_{cr}$ ($\rho\leq0.01$), which was fair for the categories 'abilities' and 'skills'. The difference between the figures for the experimental and control groups was linked with the use in the experiment of a pedagogical methodology developed by the authors. The figures for the category 'knowledge' in the control and experimental groups were approximately the same, with the difference in the figures not being statistically significant ($Q_{emp}<Q_{cr}$ ($\rho \leq 0.05$)). This may be explained by the fact that in this subject area professional competencies are mainly fostered based on one's abilities and skills.

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