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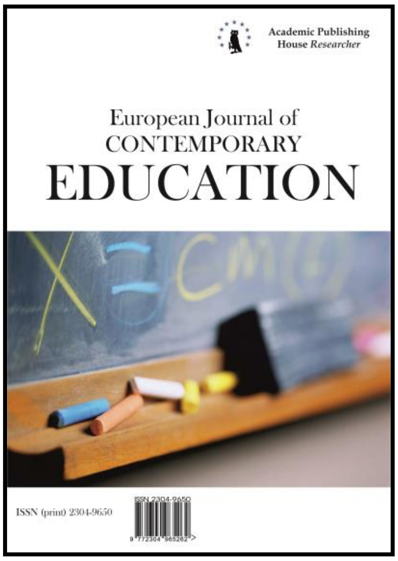

Visualization in Basic Science and Engineering Education

Rushan Ziatdinov (Ed.)

Advantages of Using the CAS Mathematica in a Study of Supplementary Chapters of Probability Theory

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Abstract

Typical difficulties in learning probabilistic subjects are concerned with big data, complicated formulas and inconvenient figures in statistical analyses. The present research considers the usage of innovative teaching methods (e.g. electronic summary of lectures, presentations of lecture courses, task solution templates, electronic training materials for seminar studies) supported by the CAS (computer algebra system) Mathematica, as suggested by the authors for several topics of the course 'Supplementary Chapters of Probability Theory'. These methods help to solve tasks requiring routine calculation and simplify the ability to find analytical and graphical dependencies in the tasks under consideration. Visualisation possibilities built in the CAS contribute to students' comprehension of new theoretical material and complicated probabilistic notions. The article contains examples of CAS-performed tasks including the calculation and visualisation of the notions of the conditional probability density function, conditional expectation, order statistics and running maximum. The purpose of the suggested CAS-based materials is to solve a whole class of tasks of similar types; it is possible to obtain new results by varying the input data without spending much time elaborating the solution method.

The methods using innovative teaching materials yield advantages to both students and teachers. These methods simplify and individualise the process of education, shorten the time necessary for students' independent work and motivate students to achieve the results. Moreover,

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the preparation and renovation of the bank of tasks of varying levels of difficulty require much less time. Consequently, teachers and students have more time to devote toward discussing and analysing the results obtained. Another possible effect of using the novel teaching means is reducing the differentiation in students' training levels. In the present research, examples of teaching materials and scenarios of their usage are presented.

In order to clarify possible scenarios of using the suggested methods, the authors explored the necessity of their modifications, and assessed students' attitudes toward the aforementioned education methods as well as toward traditional methods, the advantages and difficulties of their usage are also explored. For this purpose, students were asked questions, and their answers have been analysed statistically. The research demonstrates that students regard interactive templates as complicated and difficult to understand; however, they do not conclude that they are unnecessary. The most remarkable aspect for students is the convenience of work with mobile devices and the possibility of a full-text search. However, the students did not make a connection between the interactive templates and the presentations prepared with their use. One can conclude that students should begin learning CAS in the first term of their university education. Additional adaptation of the teaching materials for mobile devices is necessary as well.

Keywords: CAS – computer algebra systems, correspondence analysis, Mathematica, mathematical statistics, mobile device, questioning, random process, teaching means, visualisation.

1. Introduction

Actual problems of modern science and technology require new education methods consistent with the applied direction of education (Sezonova et al., 2016). Students must learn to construct mathematical models of natural phenomena by applying the achieved skills. They must also be able to perform computer experiments with the models and draw conclusions from the results of a calculation.

The inclusion of computer technologies in the process of education and the development of on-line methods have two effects: they individualise the education process and allow for the possibility to collect data on students' education outcomes (Barba et al., 2016). Previous studies (Ivaniushina et al., 2016), (Ipek, Ziatdinov, 2017) have considered the particularities of a contemporary teaching environment that incorporates computer technologies. In regard to the visualisation of mathematical objects, e.g. functions of a complex variable (Troup et al., 2017), Taylor polynomials (Wojas, Krupa, 2017) play an important role in new education technologies and enable students to comprehend complicated mathematical notions.

Problems requiring the numerical analysis of big data are typical for modern technology (Psycharis, 2016; Rau, 2017). Often, an analytical solution of such problems turns out practically impossible. Therefore, the capability of a numerical solution and modeling becomes particularly important; thus, programming and mathematical packages ought to be included in education curriculum. Their successful mastering is necessary for a time-effective solution to problems that future engineers will encounter.

Mastering various program languages is not easy for students who have not studied them in school, and learning them requires a considerable amount of time (Broley et al., 2018). As a rule, it is sufficient for students of several specialisations to master certain program languages. Using CAS (computer algebra systems), such as MATLAB, Maple, and Mathematica, is preferable. The advantages of these program languages include their convenient interfaces and the presentation of mathematical expressions in a form familiar to students (Garner, 2004; Vlasova et al., 2017b).

Ivanov et al. (2017) discussed the application of the CAS Mathematica when teaching the course Discrete Mathematics. They specifically addressed Mathematica's main advantages and the possible ways to overcome certain difficulties. Issues related to teaching the probabilistic subjects (Vlasova et al., 2017a), especially Mathematical Statistics and Random Processes, should be investigated as well.

The probabilistic subjects (Probability Theory, Mathematical Statistics and Theory of Random Processes) hold a special place among mathematical subjects in the structure of modern education. These subjects are closely concerned with practice; their applications are significant since they deal with mathematical models of statistical conformities to natural laws. Statistical methods are widely used in technical and economical sciences due to the development of mass processes in industry, as well as experimental techniques and the necessity of a subtle analysis of experimental data. For a successful analysis of stochastic phenomena, one needs to construct, choose and verify mathematical models to generalise experience and known problems of research. Therefore, vast knowledge of the fundamental branches of mathematics (i.e. Analytic Geometry, Calculus, Differential Equations, Linear Algebra etc.) is required. Even if certain engineers do not have to apply statistical methods in their professional activities, they still need to be familiar with the basic notions and ideas of probabilistic sciences in order to understand their conclusions (Lai, Savage, 2013; Kvasz, 2018).

Typical difficulties associated with learning probabilistic subjects are concerned with big data, complicated formulas and inconvenient figures in statistical analyses of data (Holmes, 2003). In terms of another difficulty influencing the choice of an education strategy, it is possible that many students have not trained enough in mathematics in general; students' fear before certain STEM subjects should also be taken into account (Fatikhova, Sayfutdiyarova, 2017; Morán-Soto, Benson, 2018). In order to overcome these difficulties, students ought to learn computer-based methods of data analysis. One can use personal computers or tablets with special program complexes installed to solve task problems (Harrison, Lee, 2018; Davidovich, Yavich, 2018). Numerical technologies essentially contribute to one's education, allowing for a more thorough understanding of the subject studied and its laws (Kidro, Tall, 2015).

For the sake of mastering theoretical knowledge in the course 'Probability Theory, Mathematical Statistics, and Random Processes', computer lab works, including modeling and numerical experiments, are organised (Karakış et al., 2016; Mezhennaya, Pugachev, 2018). These works supplement and illustrate the mathematical theory with examples and actual calculations. Teachers shall provide students with detailed instructions for computer-solving probabilistic tasks by using program packages, including those adapted for mobile devices (MATLAB, Maple, Mathematica, etc.). The ability to construct interactive patterns of solutions to certain types of problems is another advantage of using CAS (Abell, Braselton, 2009; Fisher, 2014). When a user modifies the input data of a problem, a template automatically modifies the results of all steps of the solution in analytical or graphical form.

In the present work, new CAS-based teaching methods for probabilistic subjects are considered. The authors' suggested approach consists of supplementing the didactic complex of the subject (consisting of traditional teaching means, e.g. a manuscript summary of lectures and seminar studies, electronic training materials to seminar studies, electronic materials which help with at-home task) with innovative teaching means designed using the CAS Mathematica[*]. Presentations of the lecture course and task solution templates prepared using Mathematica are suggested. The presented material includes graphic forms; it is based on the visualisation tools built in Mathematica.

The methods that incorporate innovative teaching materials yield advantages to both students and teachers. These methods simplify and individualise the process of education, shorten the time required for students' independent work, and motivate students to achieve the results. The main advantage for teachers is that they do not have to spend much time preparing tasks with convenient numbers. On the other hand, there is the potential for the fast generation and renovation of the bank of tasks of varying difficulty levels, and the supplementary possibility of involving students in the process of education. Additional opportunities for a bilateral discussion and analysis of the obtained results exist. Another possible effect of using the innovative teaching means is a reduction in the differentiation of students' training levels. In the present research, examples of teaching materials and their usage scenarios are presented.

The materials have been prepared for fourth-year students of engineering specialisations at Bauman Moscow State Technical University (BMSTU). They are enrolled in the course 'Supplementary Chapters of Probability Theory' in the seventh or eighth half-year term.

It is well known that joint work of a student and a teacher is necessary for the achievement of positive education results (Ivaniushina et al., 2016). Therefore, it is important to take the students' opinions on new education techniques into account. For this purpose, the authors gave questionnaires to the students; statistical analysis of their responses is presented in this paper.

[*] The CAS Wolfram Mathematica with license number L3253-3375 is used.

This research attempted to clarify students' attitude toward CAS-based materials and analysed their usage frequency and scenarios. Such an analysis will provide insight into changes that are needed in the education process and with the materials used. For instance, the materials can be modified according to students' needs and the stated education purposes and to improve teachers' 'client first' approach. The additional advantage of these methods is their flexibility in achieving the purposes of education, which is determined by their future use in the professional activity — e.g. a computer analysis of engineering data, the construction of neural network models etc.

2. Materials and Methods

2.1. Conditional distributions in a two-dimensional normal law

One of basic notions engineers exploit in practice is a normal distribution on a plane. Therefore, mastering this notion is highly important in the course Probability Theory, which is taken by students of engineering specialisations. It is well known that students mainly perceive the formulas concerned with a two-dimensional normal law as overly complicated and that analytical manipulations necessary for establishing the properties of this law (e.g. the calculation of its conditional expectation) are considered as an arduous routine. Therefore, it is important to use a CAS to depict and focus on graphical illustrations and to obtain answers.

The authors suggest to begin with constructing the graph and level lines of the density function of a two-dimensional normal distribution with both component, x and y, having the standard normal distribution. Their correlation coefficient is r ($-1 < r < 1$). It is necessary to consider two different values of r in order to recall and clarify its meaning. See the graphs in Figure 1.

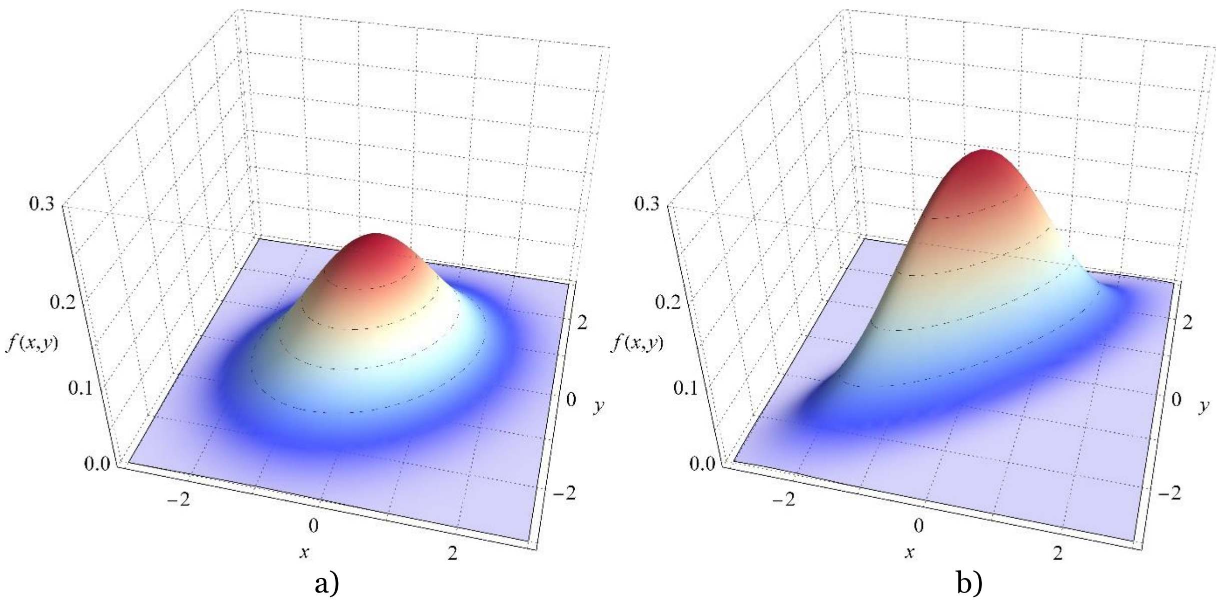
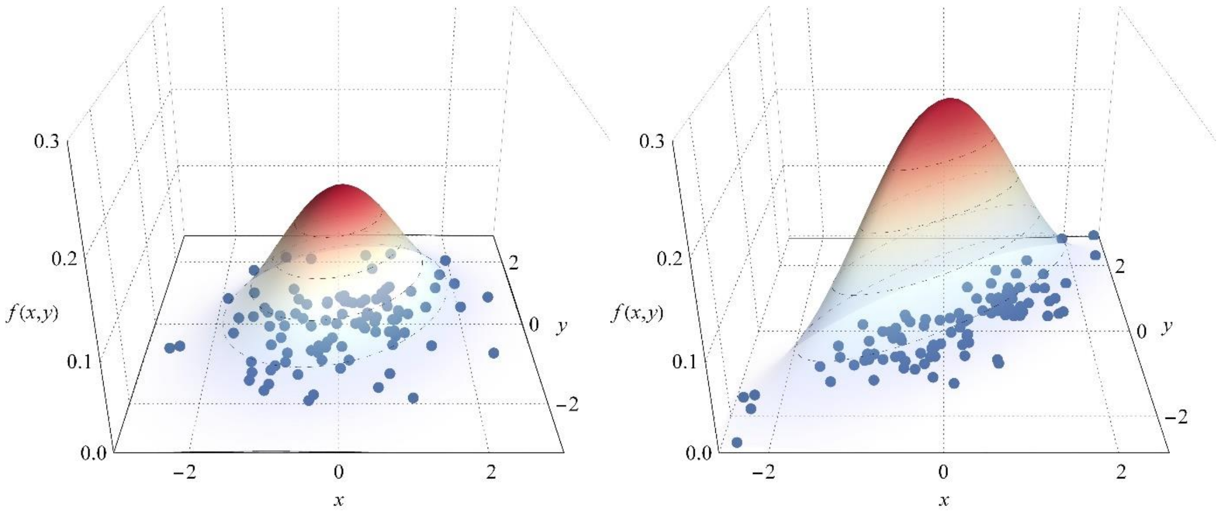


Fig. 1. Graphs of density functions of two-dimensional normal distributions with each component having the standard normal distribution and the correlation coefficients r: a) r = 0.3; b) r = 0.8

Figure 2 presents the scatter plot of a sample consisting of 100 values obtained from a two-dimensional normal distribution, in comparison with its probability density function. Note that the CAS Mathematica is capable of creating animated figures that show how a distribution changes depending on the value of r; one can demonstrate such animation within the course of lectures.

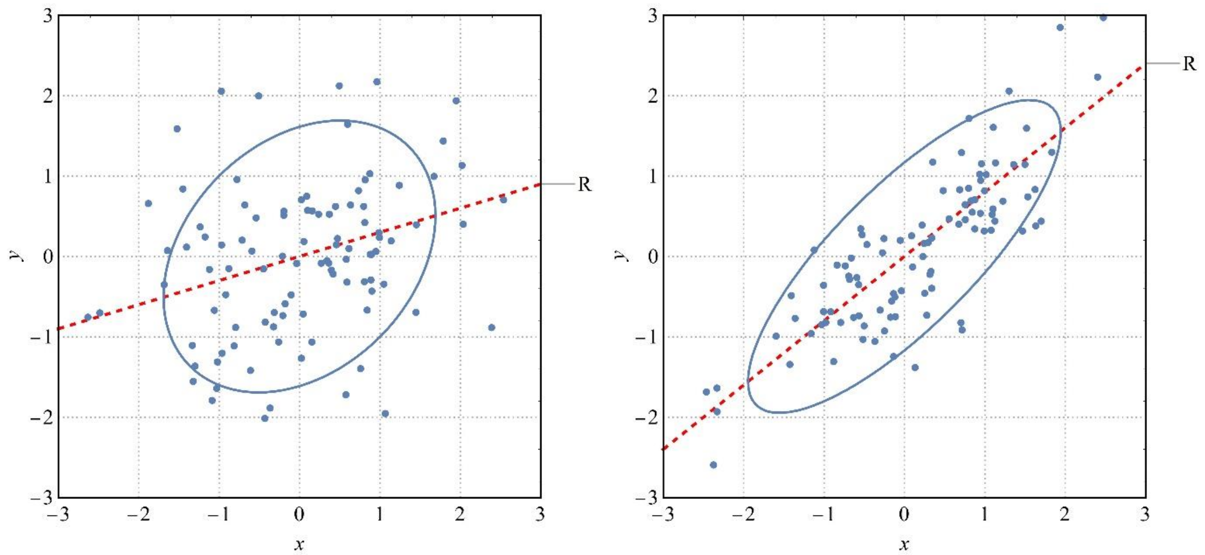


a) b)

Fig. 2. Graphs of density functions of two-dimensional normal distributions combined with their scatter plots: a) correlation coefficient r = 0.3; b) r = 0.8

In Figure 1 and Figure 2, it is evident that the correlation coefficient influences the form of the graph of density function and the cloud of points.

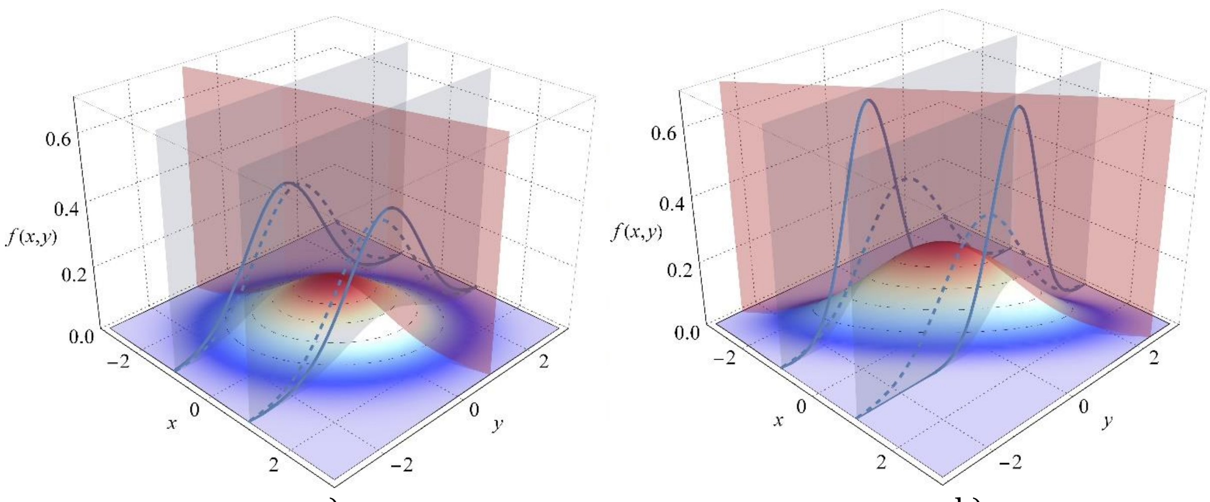
Figure 3 illustrates the plain projections of the objects shown in Figure 2.



a) b)

Fig. 3. Level lines of density functions of two-dimensional normal distributions combined with their scatter plots and the regression lines R of y with respect to x for different values of the correlation coefficient: a) r = 0.3; b) r = 0.8

The next illustration (Figure 4) clarifies the notion of the conditional density function of the component y in the case of the known value of x. For this purpose, the graphs of the probability density function, the regression line and the conditional and non-conditional density functions of the component y are combined for a known value of x. The graphs depict one-dimensional density functions corresponding to two different values of x.



a) b)

Fig. 4. Graphs of density functions of two-dimensional normal distributions, the planes of regression of y with respect to x (red), conditional density functions (solid lines) of y under the conditions $x = -1$ and $x = 1$ (in the gray vertical planes) and non-conditional density functions (dash lines) of y: a) correlation coefficient $r = 0.3$; b) $r = 0.8$

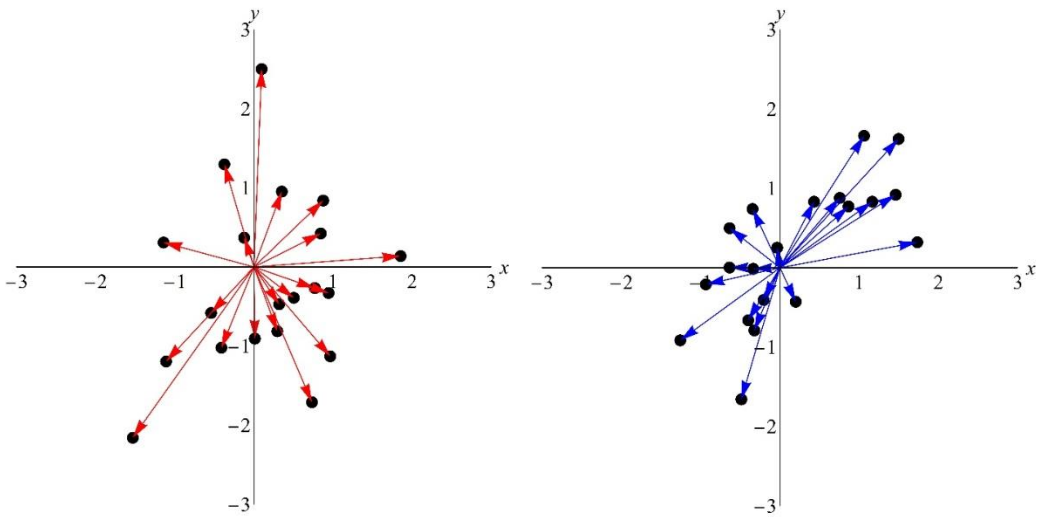
The graphs present a detailed explanation of the meaning of the correlation coefficient and its influence on the form of the cloud of points and the conditional probability density function. Moreover, the teacher can provide the students with CAS Mathematica code files for an independent study or for use in lab work, in order to show how its usage enables one to quickly and effectively perform routine calculations, whereas one obtains the answer in the traditional mathematical form.

2.2. Functions of normal random vectors

It is reasonable to explore the distributions of a normal random vector's functions. Consider the following task statement: The random values X and Y have a two-dimensional normal distribution; hereby, each component has the standard normal distribution, and their correlation coefficient is r. Consider the problem of finding the probability density function of the length R of the radius vector of a point with coordinates (X, Y), i.e.

$$R = \sqrt{X^2 + Y^2}.$$

Figure 5 illustrates this problem in the cases of two different values of r.



a) b)

Fig. 5. Clouds of points and the corresponding values of radius vectors for a sample volume of 20 from two-dimensional normal distributions: a) for r = 0; b) for r = 0.8

It is well known that in the case of $r = 0$ (Figure 5, a), the value R has a Rayleigh distribution; if the correlation coefficient is nonzero, then the probability density function of R should be expressed via special functions, and it is difficult to calculate analytically. Nevertheless, the corresponding expression is easy to find in the CAS Mathematica. Below, Figure 6 shows the scatter plots of random samples of R and the graph of its probability density function for two different values of correlation coefficients.

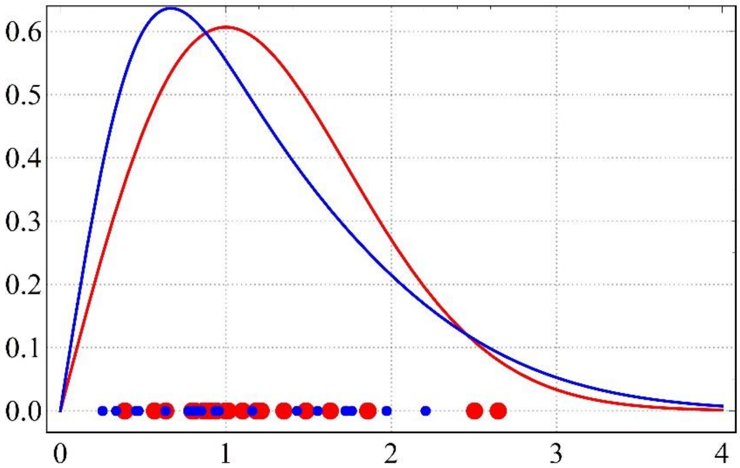


Fig. 6. Scatter plots (sample volume = 20) of length R of the radius vectors of normally distributed random points and the graphs of probability density functions of R: red colour corresponds to $r = 0$; dark blue corresponds to $r = 0.8$

Figure 6 enables one to compare the probability density functions corresponding to different correlation coefficients. Although the difference in the shape of the graphs of probability density functions seems insignificant, it appears that the distribution corresponding to $r = 0.8$ possesses a significantly heavier tail, as one can see in the diagram.

2.3. Conditional expectation of minimum under a known value of maximum

Let X_1 and X_2 be independent random values with the same Rayleigh distribution. Consider the new random values

$$Y_1 = \min\{X_1, X_2\},\ Y_2 = \max\{X_1, X_2\}.$$

The authors made a graphical illustration of the notion of conditional expectation $\mathbf{E}(Y_1|Y_2)$. First, they generated a sample of 100 values of the random vector (X_1, X_2); next, they transformed it into the sample of 100 values of the random vector (Y_1, Y_2). In Figure 7, the first set of points appears in a dark blue colour; the transformed set of points is shown in red.

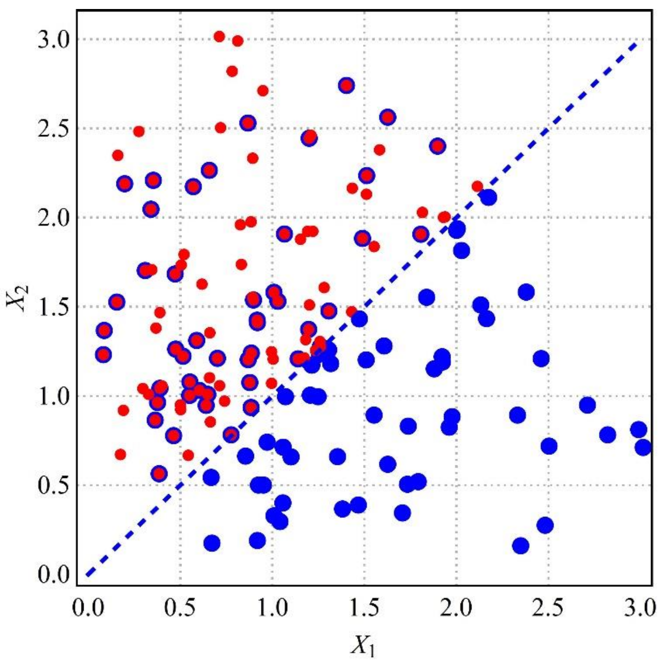


Fig. 7. A cloud of 100 sample points of the random vector (X_1, X_2) (dark blue points) and the corresponding 100 points of the random vector (Y_1, Y_2) (smaller red ones). The dark blue dash line is the reflecting screen (the bisector of the first quadrant)

The next figure (Figure 8) illustrates the notion of the regression line. The scatter plot of the random vector (Y_1, Y_2) is combined with the regression line and the reflecting screen.

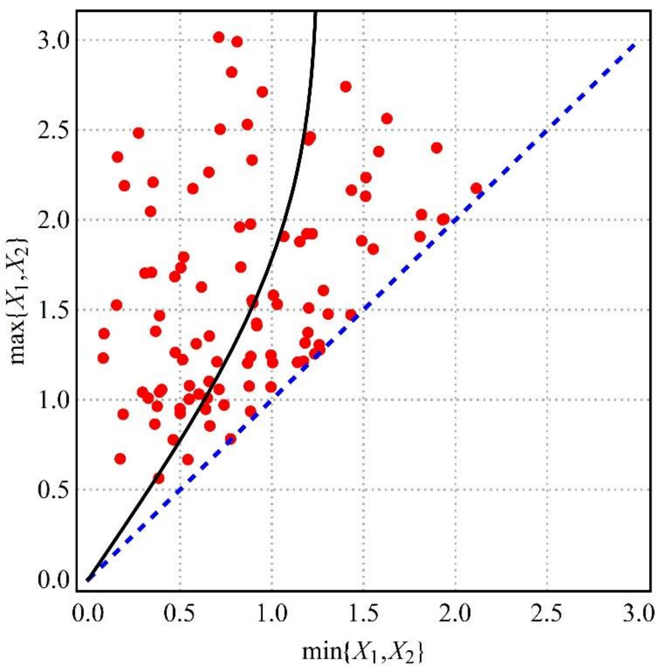


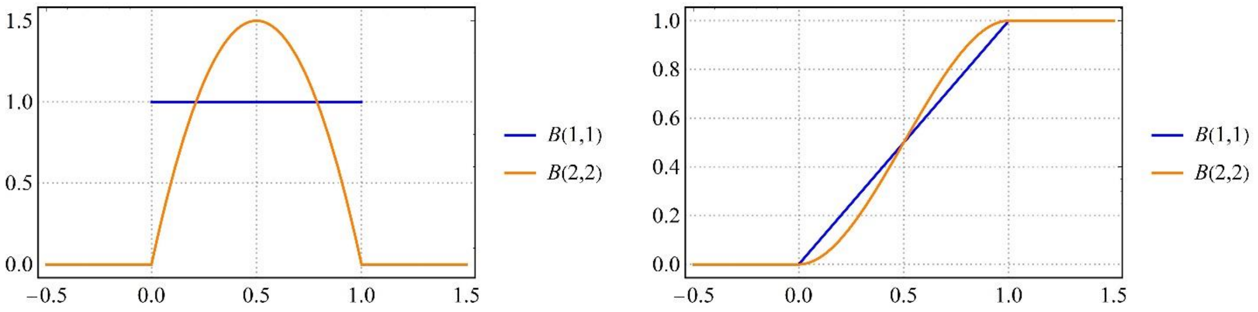
Fig. 8. A cloud of 100 sample points of the random vector (Y_1, Y_2) (red points) and the regression line $y_1 = \mathrm{E}(Y_1|Y_2 = y_2)$ (black solid line). The dark blue dash line is the bisector of the first quadrant

This way, one can use the graphical possibilities of CAS Mathematica for a simple explanation of the often difficult to understand notion of conditional expectation.

2.4. Comparison of samples of Beta distributions

Consider the random values X and Y distributed in the segment [0;1] as having different laws of distribution: X is uniformly distributed, and Y has B(2,2) distribution. Note that the uniform distribution is the same as B(1,1). Both distributions are symmetric with respect to the middle of the segment, but they have different density functions. The task is to observe resemblances and differences in the characters of the distribution laws of X and Y to demonstrate non-evident differences in their distributions and to clarify the basic notions and laws of sampling theory.

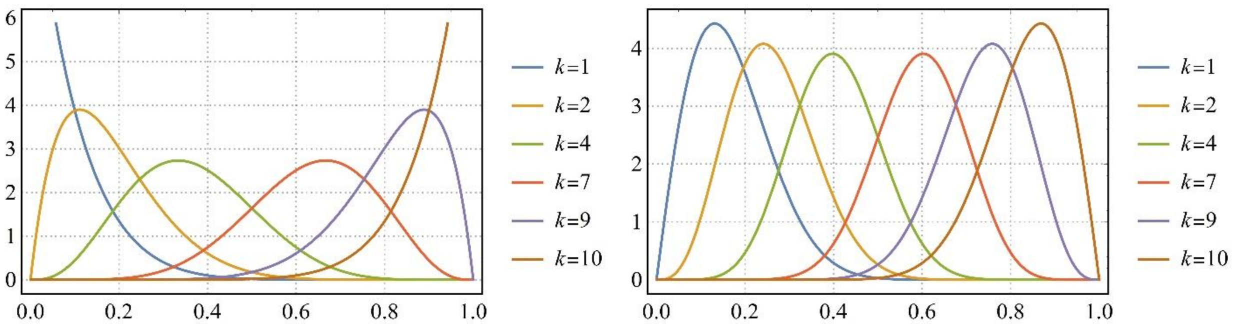
The researchers constructed the graphs of probability density functions and distribution functions of X and Y. For this task, they used functions built in the CAS Wolfram Mathematica. Figure 9 shows the results of running the commands.



a) b)

Fig. 9. Graphs of probability density functions (a) and distribution functions (b) of the laws B(1,1) and B(2,2)

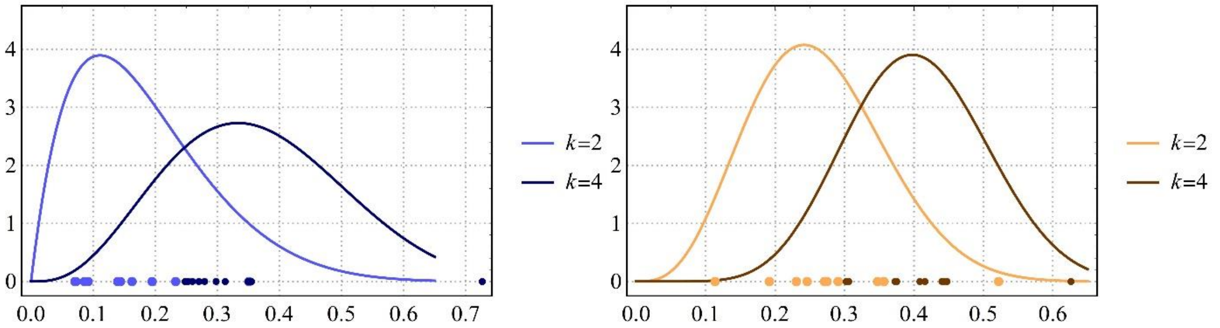
The authors then explored the distributions of the order statistics. They used the well-known formulas of their probability density functions (Van der Waerden, 1969) and constructed their graphs (see Figure 10).



a) b)

Fig. 10. Graphs of probability density functions of the k-th order statistics, k = 1, 2, 4, 7, 9, 10, for samples of volume 10 from the laws B(1,1) (a) and B(2,2) (b)

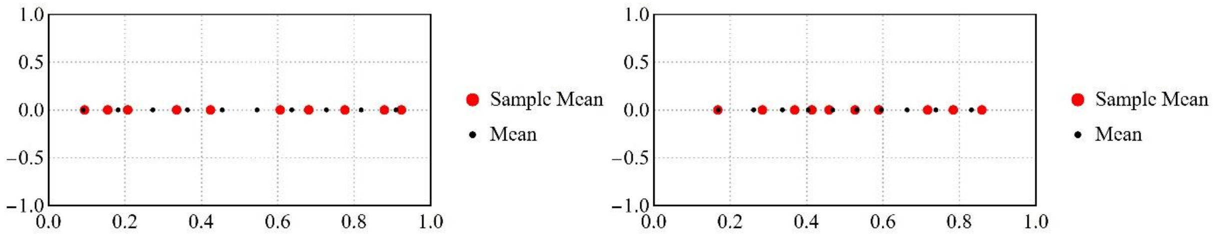
In addition, one can illustrate these graphs with samples of the order statistics obtained. To do so, generate 10 samples, with each having volume 10, from the laws B(1,1) (a) and B(2,2) (b). Figure 11 shows the graphs of probability density functions of the second and the fourth order statistics and the samples of their obtained values.



a) b)

Fig. 11. Graphs of probability density functions of the second and the fourth order statistics of samples of volume n = 10 from the laws B(1,1) (a) and B(2,2) (b) and samples of volume 10 of their values (points below the graphs)

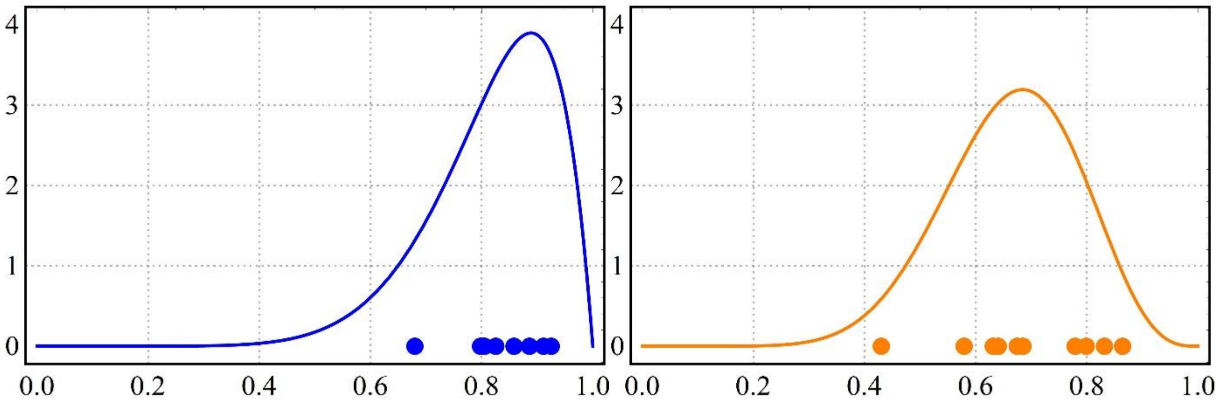
The researchers then compared the sample mean values of the order statistics of 10 samples with their theoretical values obtained via numerical methods. Figure 12 shows the results of running Mathematica commands.



a) b)

Fig. 12. Sample mean values of the k-th order statistics (k = 1,…, 10) compared with their theoretical values for 10 samples of volume n = 10 from the laws B(1,1) (a) and B(2,2) (b)

The researchers completed the example by exploring the problem of distribution of the sample range. For this purpose, they found analytical expressions of its probability density functions. In the case of the B(2,2) law, the expression is too bulky; thus, it is difficult to calculate it without using a CAS. But if one uses Mathematica, the density functions can be found quickly and effectively. Next, plot the probability density functions of the sample range of the two laws under consideration and compare them with the empirical values obtained earlier (Figure 13).



a) b)

Fig. 13. Scatter plots of sample ranges (sample volume = 10) for the laws B(1,1) (a) and B(2,2) (b) and their probability density functions

The graphs clarify differences between the distributions of the samples.

2.5. The Wiener process distribution and running maximum

The topic of normal laws of distribution, as discussed in section 2.1, closely relates to exploring the properties of one of the most well-known random processes: the Wiener process.

First, it is important to review the properties of one-dimensional distributions of the standard Wiener process w_t (Figure 14).

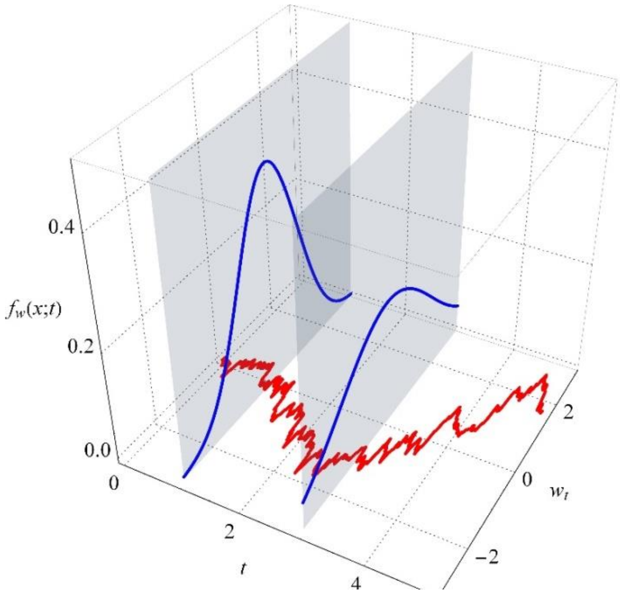


Fig. 14. A path of the standard Wiener process w_t (red line) and its probability density functions at the moments t = 1 and t = 3 (dark blue lines)

As Figure 14 demonstrates, the probability density function changes as t increases: whereas the mode is constant, the volatility increases.

In the same way, one can explore the conditional laws of distribution under a known value of the process during a fixed moment in time (Figure 15).

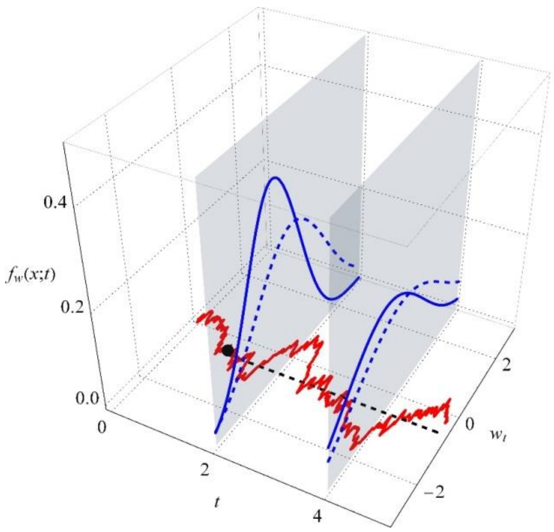


Fig. 15. A path of the standard Wiener process w_t (red line), its conditional expectation $E(w_t|w_1=x_0)$ (black dash line) and conditional probability density functions at the moments t = 2, 4 (dark blue solid lines). The dark blue dash lines show the non-conditional probability density functions at the moments t = 2, 4 for comparison

Figure 15 enables one to compare the conditional and non-conditional probability density functions of a Wiener process during the same moment of time (the solid dark blue lines and the dark blue dashes, respectively). Moreover, Figure 15 demonstrates the fact that knowledge of the value of the process at a given moment of time decreases its volatility.

The running maximum is expressed as m_t, i.e. the maximum of a standard Wiener process w_t until the moment t. Figure 16 clarifies the notion of m_t.

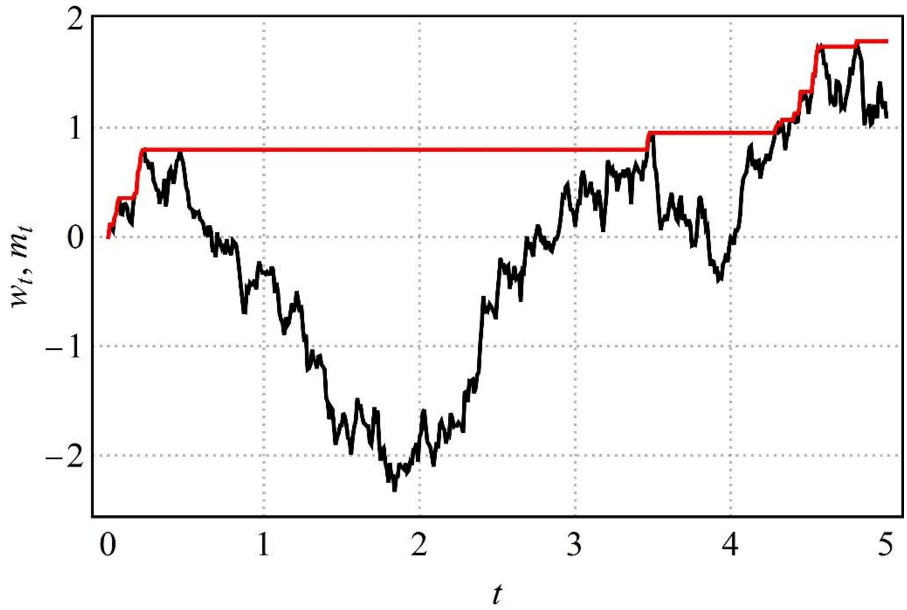


Fig. 16. A path of the standard Wiener process w_t (black line) and the corresponding path of running maximum m_t (red line)

The next figure (Figure 17) shows the empirical and theoretical distribution functions of m_t at a given moment in time, i.e. t. Figure 18 presents its histogram and probability density function.

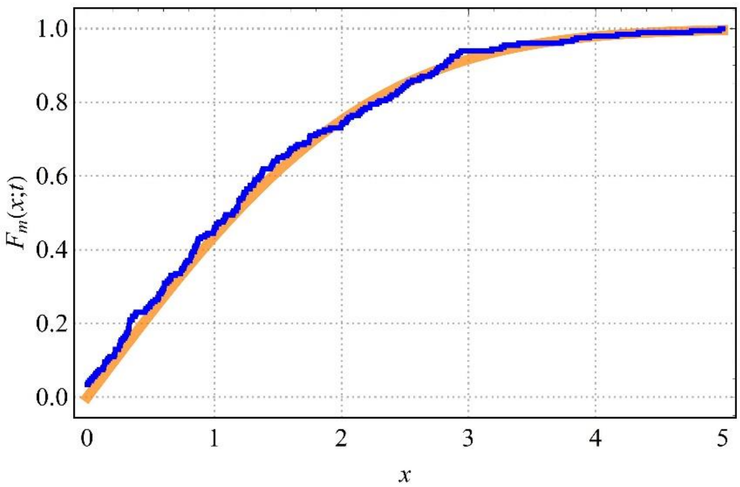


Fig. 17. Graphs of theoretical (orange line) and empirical (dark blue line) distribution functions of the running maximum m_t

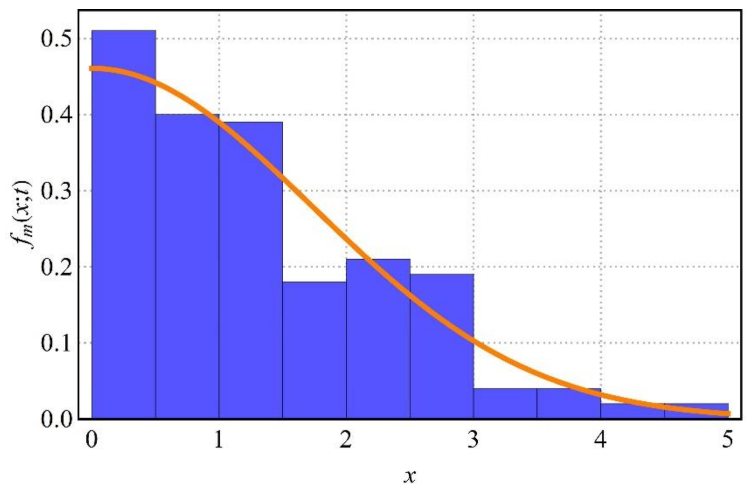


Fig. 18. Graph of theoretical probability density function (orange line) and a sample histogram (dark blue) of the running maximum m_t

A comparison of the empirical and theoretical laws of distribution is especially important for understanding the foundation of the sampling method. Moreover, the examples under consideration clearly demonstrate how one can apply the simplest statistical laws to study much more complicated notions such as the running maximum.

3. Methodology of the Research

3.1. General background of the research

Research on students' attitudes toward various teaching methods (e.g. a manuscript summary of lectures, an electronic summary of lectures, presentations of the lecture course prepared using CAS Mathematica, manuscript materials for seminar studies, electronic training materials for seminar studies, electronic methodic materials that help with at-home tasks, task solution templates prepared using CAS Mathematica) has been conducted. The research includes data derived from the responses of fourth-year students (165 students, 98 male and 67 female, aged 20 to 27 years) who took the course 'Supplementary Chapters of Probability Theory' in the years 2016-17 and 2017-18. A questionnaire consisting of four questions that focused on gender, age, the applied teaching methods and students' attitudes toward such methods was used as a data collection tool for the research. The purpose of the study was to determine the main advantages and disadvantages of the applied methods in order to improve them in the future. The sample data were collected from December 2016 until June 2018 and were analysed in June–July 2018.

3.2. Sample for the research

The research included a questionnaire that was given to fourth-year students who had learned 'Supplementary Chapters of Probability Theory' and agreed to take part in the survey. All of the students were in their fourth year at Bauman Moscow State Technical University during the years 2016-17 or 2017-18. The research presents the data of those students who accurately completed the questionnaires. In other words, they provided answers to all of the questions, without any contradictions in their answers to questions 3 and 4. (The questionnaires that did not include a teaching means in response to question 3 but included its evaluation in question 4 were not taken into account). As a result, a total 165 questionnaires were chosen for statistical analysis. Eleven questionnaires were excluded due to their lack of demographic data or mistakes related to questions 3 and 4. The interview procedure eliminated the possibility for discussions and cribbing.

The research includes the sample data collected from the questionnaires completed by 165 students (98 male and 67 female) aged 20 to 27 years. Their mean age was 21.72 with a standard deviation of 0.84. Such a distribution in gender and age is typical for students of technical specialisations.

All the data about the students and their education outcomes were presented in impersonal form. In other words, in the research, the authors did not include the students' names, specialisations and groups, their education marks or their answers. Only the obtained quantitative data on education outcomes and the questioning results were analysed.

3.3. Instrument and procedures

The questionnaire, as presented in Table 1, included four questions and was the tool of research. The main purpose of distributing a questionnaire to students was to compare and analyse their attitudes toward traditional teaching methods (e.g. manuscript and electronic summaries of lectures, manuscript materials for seminar studies, electronic training materials for seminar studies, electronic materials to help with at-home tasks) and innovative methods prepared using CAS Mathematica (e.g. presentations of the lecture course, task solution templates). The questionnaire contained typical demographic questions (gender and age) and asked the students about the teaching means within the half-year term. In order to determine the students' attitudes toward the applied teaching means, they were asked to assess convenience of each means based on several statements, with each statement having values of suitability that ranged from '5' (fully corresponds) to '1' (fully contradicts). Typical statements were as follows: a) this teaching means is easy to understand; b) this teaching means is easy to use at home; c) this teaching means is easy to use in city transport etc. Table 1 provides a complete list of the statements.

It is commonly known that modern education programmes involve many components; as such, many students view the time assigned to independent work as insufficient. Consequently, students often do not have enough time and/or motivation for an independent study of a subject and to perform related tasks. Electronic presentations can clarify complicated physical phenomena; hence, they support text searches and other tools that save students' time and enable the teacher to apply the 'client first' approach. This advantage becomes particularly important during the reforming and optimisation of the education process, the aggregation of lecture audiences etc. Another reason is that penetration of interactive task templates, in addition to saving time, stimulates the development of the skills of independent solution of engineering tasks in the future.

It is interesting to clarify the students' attitudes toward these matters. The statements given in the fourth question of the questionnaire aimed to explore the following important aspects related to teaching means:

1) do they regard a certain teaching means as a) easy/difficult, b) necessary/unnecessary;

2) which scenarios of independent using the teaching means do they choose: a) using at home/fluent using (e.g. in transport);

3) does the teaching means save time (e.g. by supporting the search of text information).

Table 1. The list of statements evaluated by students

1. Your gender	□ female □ male
2. Your age (full years)	
3. Mark the teaching means you have used in this term: □ A1 Manuscript summary of lectures; □ A2 Electronic summary of lectures; □ A3 Presentations of the lecture course prepared using CAS Mathematica; □ B1 Manuscript materials for seminar studies; □ B2 Electronic training materials for seminar studies; □ C1 Electronic methodic materials that help with at-home tasks; □ C2 Task solution templates prepared using CAS Mathematica.	
4. For each of the teaching means used, mark each statement based on your impression (5 – fully corresponds, 1 – fully contradicts). If you have not used the teaching means, leave the cell empty.	

Statement / Teaching means	A1	A2	A3	B1	B2	C1	C2
Q1 This teaching means is easy to understand.							
Q2 This teaching means is easy to use at home.							

Q3 This teaching means is easy to use in city transport.							
Q4 This teaching means is suitable for quickly finding information.							
Q5 This teaching means is not convenient to use.							
Q6 This teaching means is difficult to understand.							
Q7 This teaching means saves time.							
Q8 I like this teaching means.							
Q9 I don't like this teaching means.							
Q10 This teaching means is necessary.							
Q11 This teaching means is unnecessary.							

The questioning was carried out during the 14th-16th week of each term. (It was the seventh or the eighth half-year term, depending on the students' specialisations.) Groups of students who were interested in responding to the questionnaire (no more than 20 students in each group) were invited after the studies into a lecture hall suitable for 180 students. They sat spaced out from each other so that they were unable to see each other's answers. They were given 20 minutes to complete the questionnaire. The questionnaire was anonymous and contained no personal information.

3.4. Data analysis

The collected sample data were processed with Excel, Statistica, and Mathematica. The correctness of the answers to questions 3 and 4 was checked. (As previously mentioned, the questionnaires that did not include a teaching means in response to question 3 but included its evaluation in question 4 were not taken into account). As a result, 165 correct questionnaires were chosen for statistical analysis.

3.5. Results

The overwhelming majority of students had more or less used all of the teaching means. The number of students not using each of the teaching means (question 3) and the associated percentages are provided in Table 2. Note that relatively more students ignored the teaching means C2 'Task solution templates prepared with using CAS Mathematica'. Possible reasons for this finding are students' fear prior to using program languages and the absence of equipment.

Table 2. The number of students not using each of the teaching means and the percentages

Teaching means	A1	A2	A3	B1	B2	C1	C2
Number of students not using	7	3	7	9	4	5	16
Percentage	4.2	1.8	4.2	5.5	2.4	3.0	9.7

Table 3 (below) presents the frequency with which students selected '4' and '5' for items in the fourth question.

Table 3. Frequency of '4' and '5' answers to each statement and the associated teaching means

Statement \ Teaching means	A1	A2	A3	B1	B2	C1	C2
Q1	74	89	121	92	97	102	59
Q2	99	112	132	111	117	121	109
Q3	67	122	135	69	124	120	24
Q4	89	129	127	96	125	122	92
Q5	41	26	24	37	27	21	48

Q6	37	33	27	34	19	23	59
Q7	70	112	131	90	129	134	80
Q8	89	94	121	87	98	115	64
Q9	32	23	21	24	19	14	42
Q10	134	114	102	128	109	105	98
Q11	5	4	14	12	5	8	23

Correspondence analysis (Clausen, 1998; Hoffman, Franke, 1986) was used to determine the linkage between the statements and the teaching means. Figure 19 presents the graph of eigenvalues for the data from Table 3, wherefrom one sees that two dimensions are necessary. The first dimension explains 81 % of the inertia; the second dimension explains 12 % of the inertia. Figure 20 depicts the correspondence analysis map.

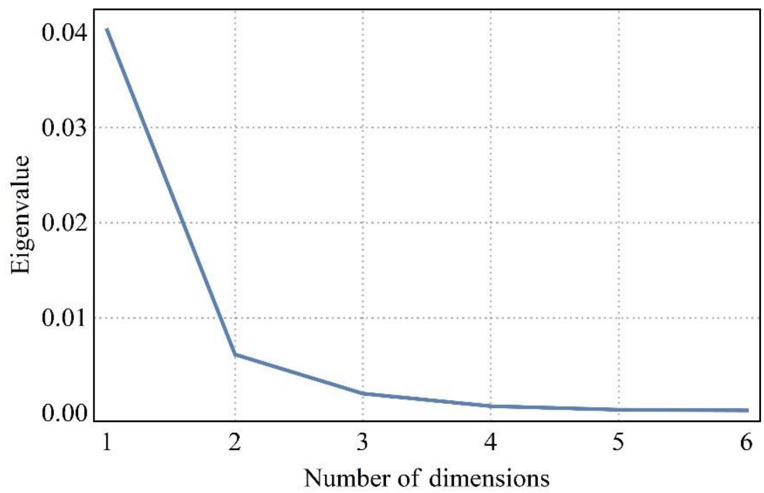


Fig. 19. Graph of eigenvalues for Table 3

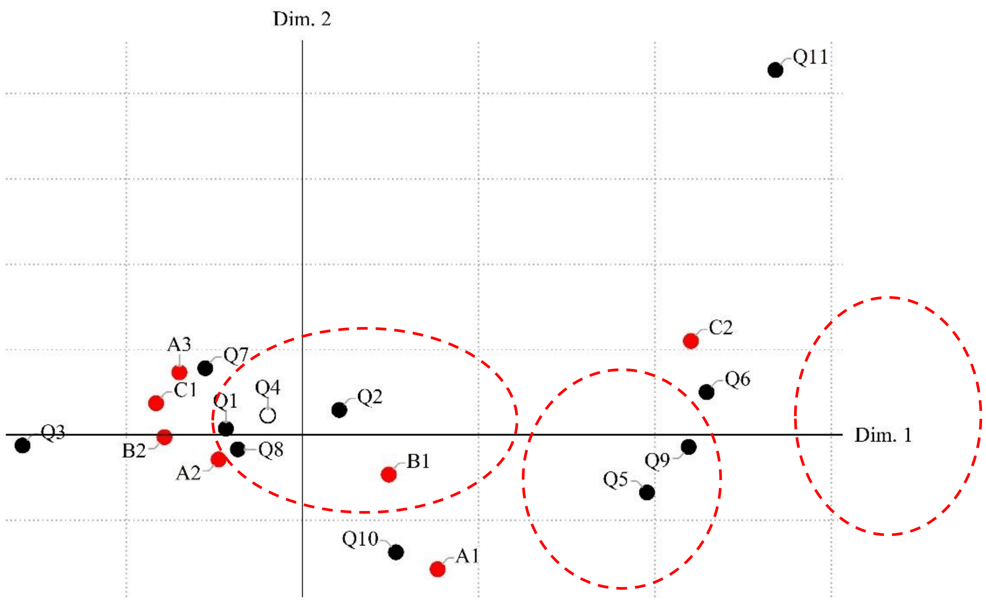


Fig. 20. Correspondence analysis map of the data from Table 3 for two dimensions. The first dimension explains 81 % of the inertia; the second dimension explains 12 % of the inertia

In Figure 20, the points corresponding to the teaching means are coloured red; the points corresponding to the statements are black. The projection of point Q4 onto the two-dimensional plane is unsatisfactory; hence, it is marked separately. For all other points, the correlation coefficients with the axes are greater than 0.5, and the quality of the projection onto the plane is good or excellent. The authors then proceeded to a qualitative analysis of the results obtained.

It is important to notice that the statement Q11 'This teaching means is unnecessary' stands separately and is irrelevant to the teaching means. The first dimension can be interpreted as 'Simplicity vs. difficulty of fluent usage' (the statements Q3 and Q6 load this dimension), the second dimension as 'Usefulness vs. uselessness of a teaching means' (the statements Q10 and Q11 load this dimension). The points make several clusters surrounded by red dash lines. The teaching means C2 stands opposite to other electronic means. One can also interpret the first dimension as 'Electronic teaching means without vs. with CAS compilation'.

The researchers then performed an analysis of the clusters and found that the statements Q5, Q6 and Q9 were associated with the teaching means C2. Therefore, for many students, the interactive templates seem complicated and difficult to understand. However, the students did not conclude that this means is unnecessary. There are several reasons for this finding. First, many students are unfamiliar with CAS, and the syntax of CAS strongly differs from traditional program languages. Hence, students do not understand how to modify the input data to obtain the answer. Second, the CAS Mathematica is not effectively adaptable on mobile devices, especially if calculations are complicated. Students remarked that they would like to be able to calculate fluently using a smart phone or a tablet.

The traditional teaching means A1 and B1 were expectedly grouped together. Mostly, the statements Q2 and Q10 corresponded to them. This finding is related to students' habit of using the materials from lectures and seminars in extra-curricular work.

The other teaching means, i.e. A2, A3, B2, and C1, are electronic, and the students' attitudes toward them were approximately equal. The statements Q1, Q3, Q7, and Q8 were relevant to them. The students regarded these teaching means as simpler compared to the traditional means of A1 and B1 and more convenient to use, especially in terms of the ability to fluently apply them. The most remarkable aspects for the students are the convenience of work with mobile devices and the possibility of full-text searches. An interesting fact is that the students did not detect a strong linkage between interactive templates (C2) and the presentations (A3) prepared using these templates. Therefore, one can conclude that CAS learning should begin in the first term of students' university education.

4. Discussion

The article describes teaching methods using the visualisation capabilities of the CAS Mathematica within the course 'Supplementary Chapters of Probability Theory' for students of technical specialisations. The new teaching means—i.e. an electronic summary of lectures, presentations of lecture courses and task solution templates prepared with CAS Mathematica, and electronic training materials for seminar studies—were used alongside the usual summaries of lectures and seminar studies. The examples given in the article are concerned with the topics 'Mathematical statistics' and 'Theory of random processes'.

The teaching methods under consideration present many new possibilities to students and teachers. First, they save time during the calculation, preparation and demonstration of graphic materials. Analogous conclusions were drawn in Vlasova et al. (2017b). Moreover, it is unnecessary to choose tasks that require an elegant analytical solution. On the other hand (Psycharis, 2016), it is possible to pay more attention to the basic principles of sampling theory, which are important in future professional activities. In addition, one advantage of using CAS as handheld calculators is their capability to perform algebraic, graphic and numeric calculations (Garner, 2004). In previous research (Emmioğlu, Capa-Aydin, 2012; Ivaniushina et al., 2016; Ivanov et al., 2017), the positive impact of computer teaching methods on education outcomes was established. Moreover, the high individualisation of teaching processes and the variability of teaching purposes achieved were identified. Each of these factors has a positive influence on students' motivation.

Another advantage of used supplementary teaching means is their variability, i.e. the capability to adapt to any tasks or purposes related to education. Since stochastic conformities to natural laws must be taken into account in the analysis of real data, probabilistic subjects form a base for the further study of the professional circle of subjects (e.g. the analysis of big data, system analysis, experiment planning etc.), and for application of the obtained knowledge in practice. Interactive presentations can explain and visualise the basic stochastic laws. In addition, they provide training in skills for independent work with CAS, independent searches for the solution algorithm and the choice of the method of visualisation of dependencies. Moreover, they teach students to create certain templates that save time and can be useful for a wide range of tasks. This way, students learn to solve a certain task and to construct a solution tool so that it is maximally general and flexible. It is especially important in consideration of the expansion of new methods, such as neural net programming, machine teaching and the analysis of big data.

Note that contact and an understanding between students and a teacher in the process of education is necessary. Hence, the teaching means and their usage scenarios should be aimed not only to the certain purposes of education but also to each student's needs.

In order to clarify the students' attitudes toward applied teaching means, a questionnaire containing several significant questions about traditional and CAS-based teaching methods was developed. A total of 165 students, 59 % men and 4 1% women, completed the questionnaire. The produced samples are representative of engineering students since men more often choose scientific-quantitative occupations (Del Pero, Bychkova, 2013).

First, it is important to note that the majority of students used all of the teaching means given. Although the degree of their usage varied, a common interest in and increasing motivation to computer teaching are detectable. There are similar conclusions on computer usage in other studies (Ivaniushina et al., 2016; Ivanov et al., 2017; Korres, 2018; Psycharis, 2016).

Attention was directed toward the causes of the observed low level of usage of task solution templates prepared with CAS Mathematica. The following causes were discovered:

1. Using the desktop version of Mathematica is not always convenient; on the other hand, functions of the mobile application are quite restricted, especially if one works with big data and complicated analytical calculations;
2. Students' possible fear of STEM subjects;
3. Motivation to achieve results by using new means (e.g. program languages) instead of traditional means is insufficient;
4. Possible gender differences related to the perception and usage of various teaching means (not considered in the present article).

The first statement, i.e. the necessity to adapt the teaching materials to mobile devices, is well known (Davidovich, Yavich, 2018; Geiger et al., 2018; Ipek, Ziatdinov, 2017). The CAS developing companies have taken steps to make programs suitable on such devices. Moreover, the possible difficulties that arise from the necessity to adapt the whole course to one computing platform have been noted. It is well known that different programs are often convenient for solving different mathematical problems. Harrison and Lee (2018) discussed the criteria for choosing applications, possible difficulties and ways to partially overcoming them. In addition, research has shown that the majority of students regard program languages as the most difficult subjects (Broley et al., 2018). Hence, it is not reasonable to prepare templates using several different systems.

Other possible causes of low education outcomes exist. For instance, students may be fearful prior to difficult courses such as probability theory, statistics and programming (Griffith et al., 2012; Peng et al., 2014). Its possible consequence is that students reject the use of interactive patterns either a priori or in the first stage of a solution. In order to get over this psychological obstacle, it is necessary to perform explanatory work and to use supplementary stimulating measures, e.g. additional rating points for students using the interactive templates (Morán-Soto, Benson, 2018). Again arises the problem of motivation playing the key role in education outcomes.

In addition, it is necessary to explore possible gender differences in the perception and usage of the given materials. The hypothesis that gender differences influence students' perception of using tablets in education was posed and partially proved (Davidovitch, Yavich, 2018). Thus, while females would attribute more weight to the affective dimension, males would attribute more weight to the cognitive dimension. Further research on the influence of gender differences on perception and usage of the given teaching means is necessary for planning measures of their penetration and popularisation.

The students' attitudes toward various electronic teaching means are approximately equal. They regard these teaching means as simpler compared to the traditional means and as more convenient to use, especially in terms of being able to fluently use them. The most remarkable aspects for students are the convenience of working on mobile devices and the possibility of full-text searches. The general positive impact of electronic teaching means has been noted (Ivaniushina et al., 2016; Ivanov et al., 2017; Korres, 2018; Psycharis, 2016). An interesting fact is that the students did not detect a strong connection between interactive templates and presentations that were prepared using the templates.

5. Conclusion

Computer technologies play an essential role in almost all stages of the modern education process. Therefore, the teaching means used ought to help students and teachers achieve education purposes. The visualisation of complicated mathematical notions is especially important, and the means used must be the most simple and variable. One of the best means of this kind involves using the inbuilt graphical methods of various CAS (MATLAB, MathCad, Mathematica etc.). The article presents miscellaneous examples of using such means within learning certain topics of the course 'Supplementary Chapters of Probability Theory' and describes their advantages. In order to assess the suitability of such teaching means, the students were asked to reflect on their attitude and level of usage of each of the teaching means considered. Based on the findings, the immediate usage of CAS is regarded rather as difficult, mostly because of students' insufficient training in programming. Therefore, it is necessary to incorporate CAS into the education process beginning in the first term, especially in students' independent work.

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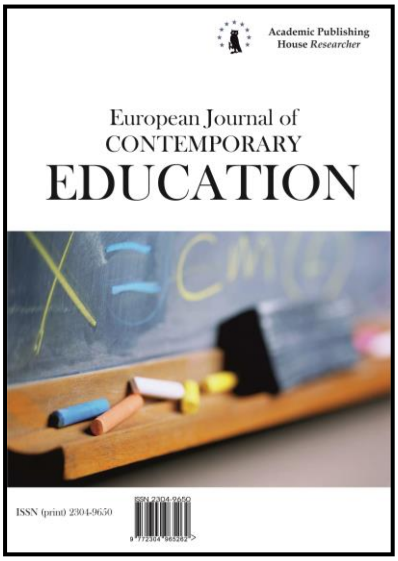

An Essential Change to the Training of Computer Science Teachers: The Need to Learn Graphics

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Abstract

The higher education system of the Republic of Kazakhstan emphasizes the need for the development of institutional science, including the field of information technology, with a priority on fundamental research. Professional training of future computer science teachers requires them to know the range of tasks related to computer graphics, and the ability to accomplish them. The training of a computer science teacher goes beyond the task solution and demands that the teacher have the basic knowledge needed in the field of computer science and information technology, and especially in computer graphics. In addition to the traditional and fundamental tasks of teaching computer graphics, the teacher is faced with the use of computer graphics elements and their tools in their teaching. It should be noted that present trends in the digitalization of education have made such tasks fundamental to teaching. Based on the above, this article analyzes the need to teach computer graphics related to the activities of future computer science teachers, and possible methods of their solutions, and the field of use.

Keywords: professional training, a computer science teacher, fundamentalization in education, computer graphics, methods of solution.

1. Introduction

The system of higher education of the Republic of Kazakhstan emphasizes the need to develop institutional science, including the field of information technology, with a priority on fundamental research (Nazarbayev, 2018). In this regard, the educational system cannot bypass the methods of training future computer science teachers in the subject field of computer science and information technology, which is characterized by a fairly high rate of updating of both the tools and technologies. The raining of computer science teachers should be done in a way that provides

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them with the opportunity to flexibly vary the direction and content of their work in response to the development and change of technologies and/or market requirements. In other words, computer science teachers should not only acquire knowledge but also develop the skills and ability to work and educate themselves by using the latest technology. In addition future computer science teachers will need to be able to teach schoolchildren the fundamentals of computer science, to help students understand that computer science is a basic science, to make them use their knowledge and skills in the field of computer science to learn other disciplines, and to aid them in their future work (Bidaibekov et al., 2010). In the Republic of Kazakhstan and many other countries, it is proposed that the government should ensure the fundamental training of teachers in computer science through the integration of information disciplines that include the use of both mathematical and information models.

The required training should consist of the introduction of the fundamental principles in most disciplines, which are in some way related to computer science. One of these disciplines, which should be studied by all future teachers of computer science in a university, are the academic subjects related to different types of computer graphics. The fundamental training of future computer science teachers in the field of computer graphics should be characterized by an emphasis on the essential foundations and links in computer graphics, and the training itself should be focused on the use of the natural internal links between computer graphics courses, computer science and mathematics, as well as other interdisciplinary connections (Bidaibekov et al., 2005). Knowledge and understanding of computer science and information technologies are essential components of the modern teacher in higher education. In this regard, the training of future teachers of computer science in the field of computer graphics should be based on the relationship between the fundamental foundations of computer science and various applied fields; the training should also promote the development of relevant professional competencies in future computer science teachers (Bidaibekov et al., 2017).

2. Classification of computer graphics tasks

The study of computer graphics during university training is an indispensable component of the professional training of any specialist in the field of computer science; it is a necessary component for the development of applied skills and the students' fundamental knowledge of computing students. In the last decade, the study of the practice and theory of training computer science teachers in universities in the Republic of Kazakhstan has revealed the need to revise the content of this training with a focus on international experience (Nazarbayev, 2018). The professional training of future computer science teachers should include a system of teaching practical skills and foster the ability to perform any educational and pedagogical task.

Teachers of computer science should be required to master a broader and deeper set of tools related to the fundamentals of computer studies. In addition to the traditional tasks of understanding computer graphics, the teacher is now faced with the use of computer graphics elements and their tools as part of their teaching.

Since the scope of application of computer graphics elements in the context of education is broad enough, the set of computer graphics tasks can be classified as a certain system. In order to apply the whole range of methodological principles for constructing a system of exercises and tasks related to computer graphics, it is necessary to identify each task's main feature(s) in order to classify them. In addition, there is a need to use the capabilities of this system to solve pedagogical problems, which are used in the professional activities of future computer studies teachers.

All of the above allows us to highlight the following requirements regarding computer graphics for the training of future computer science teachers. These include:

- the high rate of updating of means and technologies, including the field of information technologies;
- requirements of the market to form not only knowledge but also the abilities and skills needed for work and ongoing self-education using the latest means of information and digitalization;
- the need to instill students' understanding of computer studies as a fundamental science;

- exposure to the systematic use of knowledge and skills used in computer science in the studies of other disciplines, as well as developing the ability to apply them in a subsequent career;
- updating the content of the programs of the schools' computer studies classes;
- the need to use the methods and tools of computer graphics to complete pedagogical tasks; and
- the need to develop institutional science with a priority on basic research, including in the field of information technology.

Guided by the above principles, we offer a classification of the tasks that covers the training of teachers of computer studies. These include:

1. geometric tasks,
2. tasks of two-dimensional and three-dimensional graphics, and
3. tasks of study aids, i.e. pedagogical tools.

In this classification, the order of consideration of the task types is important, as each subsequent type of task implies knowledge of the previous ones. Within a single type, the tasks can be divided into:

- easy, medium and complex;
- school and university higher education course tasks; and
- standard and non-standard tasks.

Thus, the main goal is to classify computer graphics tasks while staying focused on the future training of computer studies teachers, and to offer common algorithms for their solutions.

Methods for solving computer graphics tasks depend on many factors: the type of graphics (raster or vector graphics), the dimension of the task being solved (two-dimensional or three-dimensional graphics), and the tools of the graphic system. The content and the level of task complexity are influenced by the student's level of knowledge, skills and the student's ability to master the tools of the graphic system. The fundamental basis for the successful solution of computer graphics tasks is the good mathematical understanding and ability of the future computer studies teacher.

Shvetsky (1994) believes that the fundamental element required to effectively teach computer science can be achieved through a combination of training theory, abstraction, and implementation. The study of mathematical algorithms and special data structures in a specific programming language allows students to achieve fundamental knowledge in the field of computer science (Shvetsky, 1994). This clearly implies the need to study the mathematical algorithms of raster and vector graphics, two-dimensional and three-dimensional graphics.

An analysis of the existing methods and procedures for solving a particular graphical task with the help of various tools allows us to single out the general steps needed to accomplish the task. For ease of description of the stages, we use the concept of "graphic object," which, depending on the complexity of the task, can be either a graphic primitive or a group of graphic objects.

Let us highlight the following stages of solving tasks in computer graphics, taking into account the fundamental training of future computer science teachers:

1. the study of the mathematical foundations of building a graphic object (or in the case of group objects, each individual object),
2. the study of the algorithm of computer graphics construction of the object (or group),
3. the study of tools of visualization of the graphical object (the language and programming environment, a graphical editor, and special math software),
4. computer implementation of the algorithm for building a graphical object in the selected visualization environment, and
5. an analysis of the graphical object created (an analysis of the selected method, testing the program, and saving the results).

From the point of view of the computer graphics training, the selected stages are invariants relative to the type of graphics and the dimension of the task. The tools for solving the task are variable.

Next, we consider in more detail the application of the selected steps in order to solve different types of tasks in computer graphics.

3. Methods for solving geometric tasks

It is noted that the achievement of a high level of mathematical training of students is observed in solving mathematical tasks, especially geometric tasks (Baranova, 2000). Geometry, because of its use in computer graphics is a propaedeutic course. The basic concepts of geometry – point and line – are associated with the concepts of pixel and segment in computer graphics, and the basic geometry axioms and theorems are necessary knowledge for solving computer graphics tasks. In turn, the solution of geometric tasks with the help of computer graphics tools allows the teacher to increase the students' interest in geometry, to repeat and deepen the students' knowledge and skills of solving geometry tasks, and to visualize the results of solving a geometry task.

There are a number of conditional classifications of geometric tasks: purely geometric and practical; standard and non-standard; the use of individual theorems and a combination of theorems and formulas; training, searching and problematic, etc. The most common classifications of geometry tasks are the following: to calculate, to prove, and to build (constructive problems). Geometry tasks during school are standard, use ready-made algorithms, or the algorithms are derived from definitions or theorems, are studied before applying them to computer science lessons, and do not require a lot of time to study the mathematical solution of the task during the study of computer science.

Geometrical construction tasks are those tasks that are achieved (solved) with the help of a compass and a ruler, and at the modern stage of development of information technologies, in the corresponding graphic editor. Geometrical construction tasks are a component of elementary geometry and have great potential for teaching students to choose a method for solving them and applying them in practice. Geometrical construction tasks also have close inter-subject connections with drafting courses, algebra and physics. The formation of skills and abilities to solve geometric construction tasks is important in school geometry courses in the Commonwealth of Independent States (CIS) countries, including drawing courses. A number of studies during the mid-20th century are devoted to methods for solving these tasks, among which are the works of Alexandrova (1954) and Olifer (1955).

Over the past sixty years, the importance of geometric tasks in the school courses in the CIS countries has gradually been decreasing (a decrease in the number of hours is observed, although their role is quite large). It is possible to compensate for this deficiency by making interdisciplinary connections between geometry and computer studies. Olifer (1955) proposes using construction tasks as a means of establishing relationships between geometry and practice, and proposes the following classification of these tasks: tasks for the construction of polygons, tasks for the construction of circles or arcs, tasks for the construction of lines or segments, and tasks for the construction of points. The analysis of the programs and textbooks of the school courses of computer studies in Russia and the Republic of Kazakhstan shows that such a range of tasks are offered to students to solve them (or rather, build) in a graphic editor or using a programming language.

In the course of "Computer Studies" for grades 6-7 (Makarova, 2000) the use of a raster graphics editor has been proposed to solve geometric tasks. The authors propose to study algorithms and technologies for working with graphical objects, including cyclic algorithms. The following tasks are suggested: with the help of graphic primitives (tools) to draw a house, a snowman, a plan of the terrain, the construction of a symmetrical ornament, finding the middle of a segment, the division of a square into four equal squares, and the construction of a set of inscribed squares and circles, etc.

Next, we consider the example of finding the middle of a segment.

Task 3.1. Find the middle of the horizontal segment.

Solution: This method is based on the properties of an isosceles triangle: the height dropped from the vertex of an isosceles triangle to the base is the bisector, the height, and the median. It is known that the median of a triangle divides the opposite side into two equal parts, i.e. in half.

The method of dividing a segment into two equal parts is reduced to the following actions:

1. Build a horizontal line.
2. For any end of the segment, use the Line tool to build a line at an angle of 45 degrees.
3. Similarly, from the other end, build a line.
4. From the point of intersection of the lines, lower the line to the intersection with the original segment.

Geometric constructions and their solutions were known to al-Farabi, one of the greatest thinkers and encyclopedists of the early Middle Ages. Among the numerous mathematical works of al-Farabi, a special place is occupied by the "*Book of spiritual clever tricks and natural secrets about the intricacies of geometric figures,*" the only copy of this manuscript, which is kept in the library of Uppsala University in Sweden (Kubesov, 1972). It offers unique algorithms for solving a variety of geometric tasks for construction using a compass and a ruler, which are important in the land surveying, architecture, engineering, and geodesy.

Interest in such tasks for many centuries is not only due to their beauty and the originality of the methods of their solutions, but is mainly due to their great practical value. At present, the geometric tasks of construction are also of great interest since the design of construction objects, architecture, the construction of various techniques and many other applied problems are based on geometric constructions. The huge role of such tasks in mathematical development is in the hands of the future computer science teacher. As one of the meaningful lines of the school geometry course, they are a very important element in the teaching of computer graphics, one of its integral parts (Bidaibekov et al., 2017). Among them there are a lot of tasks of different levels for the construction of regular polygons, including tasks that are unsolvable with the help of a compass and a ruler.

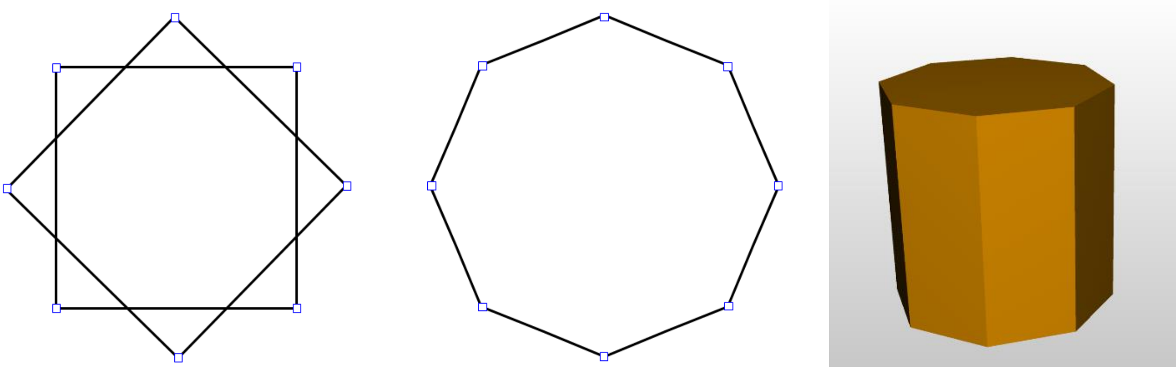
The members of the Department of Informatics and Education Informatization of Abay Kazakh National Pedagogical University propose to enrich the content of the curriculum of geometry and computer science of the Nazarbayev Intellectual School by studying geometric task construction with a compass and a ruler according to the methods and algorithms described in the works of al-Farabi.

Modern methods and procedures for solving graphic tasks allow us to build models of geometric shapes with given properties (equilateral triangle, hexagon, isosceles triangle, etc.), using the axioms and theorems of geometry, the possibility of computer graphics, and the dynamic geometry environment GeoGebra (Bidaibekov et al., 2017).

Next, we consider examples of the construction of a regular octagon according to the algorithms of al-Farabi.

Task 3.2. Modeling objects with the given geometric properties. The construction of a regular octagon.

Solution: One of the simplest methods for constructing a regular octagon is based on the construction using a regular quadrilateral and straight line segments. The method of constructing a regular octagon needed to construct two regular quadrangles and connect their vertices. Thus, it turns out to be a regular octagon (Figure 1).



(a) Overlapping two quadrilaterals and connecting vertices.

(b) A regular octagon.

(c) An octagonal prism.

Fig. 1. An example of constructing a regular octagon and an octagonal prism

Consider another task involving the constructing a regular octagon.

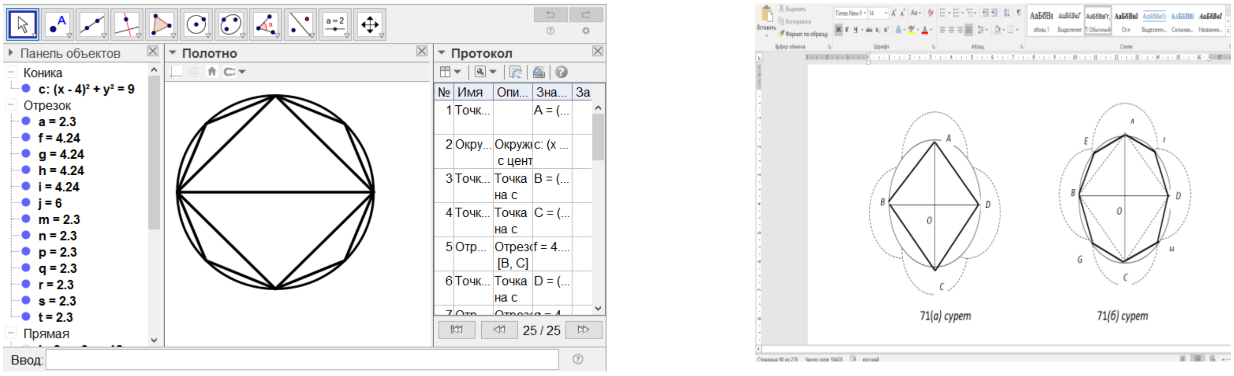
Task 3.3. Construction of a regular octagon inscribed in a circle.

Solution: al-Farabi's solution to this problem is given as follows (Kubesov, 1972). Draw a circle, build an equilateral line and equilateral quadrilateral lines in it, then split each semicircle in half, and connect the division points with straight lines with new points. We obtain an equilateral and equiangular octagon (Figure 2).

Next, we present an algorithm for solving the task of constructing a regular octagon in the GeoGebra program environment:

1. Draw a circle.
2. Fit an equilateral and equiangular quadrilateral in the circle.
3. Divide the semicircles AB, BC, CD and DA in half.
4. Divide the semicircle AB in half, mark the point E.
5. Divide the semicircle BC in half, mark point G.
6. Divide the CD semicircle in half and mark the point H.
7. Divide the semicircle DA in half, mark point I.
8. Connect the division points with straight lines with new points: A, E, B, G, C, H, D, I.

We obtain an equilateral and equiangular octagon inscribed in a circle (Figure 2).



(a) Construction of a regular octagon inscribed in a circle.

(b) External construction of a regular octagon inscribed in a circle.

Fig. 2. Construction of a regular octagon inscribed in a circle in the GeoGebra program environment.

The computer model created as a result of the constructions of the above algorithm in the software environment of GeoGebra is mathematically accurate. Computer science teachers are required to build skills using the al-Farabi algorithm in this software environment and substantiate the correctness of this algorithm based on fundamental knowledge in the field of planimetry.

Thus, the ability to solve geometric tasks, especially tasks of construction, with the help of computer graphics tools by future computer science teachers is important both for the mathematical preparation of students and for fundamental teacher training in the field of computer science and computer graphics. Geometric tasks are fundamental tasks proven essential over time, and therefore they are not subject to the development of science and technology, but only reinforce the basic content of teaching computer science, including computer graphics. Algorithms for solving geometric tasks are studied in more detail in the computational geometry section of computer science.

4. Methods for solving tasks of two-dimensional and three-dimensional graphics

Two main versions of graphic data descriptions are used in computer graphics, differing in the number of independent coordinates needed to determine the position of graphic objects and their elements – two-dimensional and three-dimensional graphics.

These kinds of computer graphics tasks are often identified with computer graphics algorithms and separated into an independent training course, which is studied in universities. In terms of the scope of the tasks, two-dimensional and three-dimensional graphics are the most extensive and range from displaying a point on the screen using a programming environment to the three-dimensional modeling of research results. The mathematical foundations of solving two-dimensional and three-dimensional graphics are laid in school when studying of geometry, planimetry and stereometry at various levels of education.

The geometric tasks we considered earlier, especially the construction tasks, are both two-dimensional and three-dimensional. These tasks can be solved both in a graphical editor and by using a high-level programming language using graphic primitives. Visualization of a graphic object in a graphic editor is a simpler and more understandable method and requires only knowledge of the algorithm for solving the task and the ability to correctly use the tools of a graphic editor. Visualization with the help of a programming language is more difficult, since it requires an additional knowledge of the functions and procedures of the particular programming language in the environment of which the algorithm will be visualized. Note that in the case of a two-dimensional construction it occurs by points (pixels), which significantly increases the time needed to execute the program implementing a particular method and therefore requires large resources of computer technology.

In the CIS countries, in the programs of the beginning of the twenty-first century of professional training of computer science teachers in universities, the purpose of teaching computer graphics was to systematically familiarize students with the mathematical and algorithmic foundations of computer graphics, the consideration of fundamental mathematical methods, principles of rotation, the transfer and change of scale of geometric shapes, methods of constructing images using axonometric and perspective methods, methods of describing curves in explicit and parametric form on the plane and in space, algorithms for constructing segments and circles, completing solid areas, truncation, the removal of hidden lines and surfaces, and the construction of realistic images (Koneva, 2010).

As a result of the study of computer graphics, future teachers of computer science should be able to formulate solutions for solving graphic tasks, choose the method of implementation, make algorithm solutions, and write a program for the formulated algorithm.

Line algorithmization and programming is an invariant component of courses of computer science, regardless of the development of information technology, and is studied in middle school, and in some cases in primary school. In primary schools a system of performers is used, which, as a rule, allows solving algorithmic tasks by graphical methods. Learning high-level programming languages is impossible without studying graphics. Essentially, each high-level programming language has the ability to support a graphics mode, built-in procedures and functions, modules and libraries, etc. For a deeper understanding of the principles of working in a graphical mode, knowledge of algorithms and methods of two-dimensional and three-dimensional computer graphics is necessary. In turn, the study of computer graphics algorithms requires the implementation of the algorithm in one of the programming languages. When studying the graphics section of high-level programming languages, such tasks as demonstrating the movement of a graphical object (point, line, ball, etc.) on the screen, text output in graphical mode, plotting a function, building visible and invisible lines and others are usually considered.

An analysis of graphic objects formulation and applying the practical skills needed for solving a range of tasks of two-dimensional and three-dimensional graphics allows the authors of this article to highlight the general stages of solving these tasks using programming in high-level computer languages:

1. Initialization of the graphics mode.
2. Defining the input and output parameters.
3. Constructing the coordinate axes (the x axis and the y axis, and in the case of the three-dimensional task, the z axis).
4. Formulating a description of the algorithm for the graphical object construction using the functions and procedures of the computer programming language.
5. Debugging the program.
6. Viewing the resulting graphic object.
7. Testing the program with various parameters (including taking "critical" points).
8. Disabling the graphics mode.

It should be noted that the solution of this range of tasks, algorithms and methods of computer graphics has an invariant theoretical fundamental nature regarding the algorithm and method for solving two-dimensional or three-dimensional graphics; the implementation of the algorithm or method in a particular graphical editor has a practical dynamic nature.

4.1. Solving two-dimensional tasks

A two-dimensional scene can be formed from objects located both in the coordinate plane and from the projections of all visible objects on the image plane. Computer graphics are replete with examples of flat scenes, such as digital photos, scanned drawings and paintings, and images created by raster or vector graphics editors. Examples of vector graphics are drawings, motion patterns, geographical maps, function graphs, and construction of cross sections of geometric figures. Studying the same material in different of the course enriches the subjects and fills them with a specific meaning.

As mentioned above, knowledge of algorithms and methods of two-dimensional computer graphics is necessary for a deeper understanding of the principles of work in graphic mode. Also, the study of algorithms and methods of creating machine graphics involves knowledge of at least one of the computer programming languages. In the programming environment, we operate "blindly" with certain functions of the graphics mode, without delving into their mathematical essence.

Let's consider an example of solving a two-dimensional task in the programming environment.

Task 4.1. Simulation in the graphic screen of a ball's movement.

Solution: To simplify the solution of the task, we will assume that the ball is initially located in the center of the screen, and after receiving a push it will move in a given direction (Burin, 2000). We assume that the ball moves at a constant speed, and when it hits the border of the graphic screen it is reflected, and the angle of reflection is equal to the angle of incidence on the border. The contact of the ball with the boundary occurs without friction. The position of the ball will be determined by the coordinates of the center of the ball. That is, the movement of the ball is fully described by the movement of its center in the rectangle of the graphic screen. The movements of the ball will be infinite unless the "Enter" key is pressed.

The algorithm for modeling the movement of the ball is as follows:

1. Initialize the graphics mode.
2. Define the input and output parameters.
3. Build a rectangular area to limit the movement of the ball.
4. Set an infinite loop before pressing the "Enter" key. Erase the image of the ball in the current position. Calculate the coordinates of the new position of the center of the ball. Bring the ball in the direction of reflection. Hold the screen to view the results of the algorithm.
5. Debug the task.
6. View the obtained graphic object.
7. Test the program with various parameters (including taking "critical" points).
8. Disable the graphics mode.

High-level computer languages display images on the graphics screen only in the form of raster graphics and to complete these tasks, the programmer must have a mathematical foundation. Understanding how to construct a program to the geometric task of construction with the help of programming language on the graphic screen allows us to look at the possibilities of using the graphics editor in a different way.

A graphic editor includes a set of tools, each of which is either a graphic primitive or an automation of some kind of computer graphics algorithm. For example, there are algorithms for filling an area and deleting invisible lines. To construct the same graphic object in different graphic editors, regardless of how the image is specified (raster or vector), it is enough to study the environment of the graphic editor and know the computer graphics' algorithm for the construction of the type of object desired. The implementation method of the algorithm will depend on the type of graphic editor (raster or vector) and on the visualization environment.

Applying the practical skills of solving a range of tasks of two-dimensional graphics in various graphic editors allows the authors of this article to highlight the general stages of the solution:

1. Studying the interface of the graphic editor.
2. Analysis of the original graphic object of the task solution (decomposition of the graphic object, selection of graphic primitives).

3. Creating a visual description of the algorithm need to construct a graphic object using the tools and features of the graphic editor.

4. Construction of a graphical object.

5. Comparison of the graphic object created with the original specifications.

6. Saving the results of the task.

Next, we will consider an example of solving a graphical task in a graphical editor.

Task 4.2. Constructing a picture of a house in a graphic editor

Solution: To simplify the solution of the task, we will assume that the real object "house" is one-story, has two windows, a roof, a door, and a porch. This task is the simplest task available for students of any level, does not require knowledge of special algorithms, and is often used as the simplest example by the authors of both school textbooks of computer studies and the educational and methodical literature on graphic editors. To study this task, it is enough for the student to draw the desired image of the house on a piece of paper. The graphic object "house" consists of the following graphic primitives: a rectangle for the base of the house, a triangle for the roof, two small rectangles for the windows, and a curve to represent the porch.

The algorithm for building a "house" is as follows.

1. Run the graphics software.
2. Study the interface of the graphic editor.
3. Break up the original graphic object into the graphic primitives.
4. Construct a picture of the "house." Select the Rectangle tool, then the Triangle, then double Rectangle, and finally the Curve tool (Bézier curve).
5. Compare the image created with the original drawing.
6. Save the image.

This kind of approach to solving tasks with the help of a graphics editor allows learning that does not to depend on the installation and study of all graphics editors; it is sufficient to install any raster editor and any vector editor. This algorithm for constructing a two-dimensional object can also be implemented in a three-dimensional modeling environment.

Within the framework of the computer graphics course, the future teachers of computer science will have previously studied the Bresenham algorithm, the floating horizon algorithm, and the Roberts algorithm. The Bresenham algorithm is one of the oldest algorithms used to construct lines on a computer screen. This algorithm is applicable to the construction of a segment, a line, a circle, and an ellipse.

An analysis of the content of modern computer graphics courses reveals that a number of modern algorithms and methods of raster graphics are not represented in this content and, accordingly, a range of tasks of computer graphics remains unexplored. Therefore, it is necessary to study the following algorithms and methods of raster two-dimensional graphics:

- output algorithms of lines: the Bresenham algorithm, Castle-Pitway algorithm, and DDA-lines algorithm;
- methods for the rasterization of Bézier curves: the direct method and splitting method;
- algorithms for clipping segments: the Cohen-Sutherland algorithm, midpoint algorithm, Cyrus-Beck algorithm, and Liang-Barsky algorithm;
- polygon clipping algorithms;
- polygon rasterization algorithms: an algorithm that partitions polygons by frequency of occurrences, a median section algorithm, and algorithms using clustering methods;
- pseudo-toning algorithms: a simple halftone approximation algorithm, an ordered blur algorithm, a Floyd-Steinberg error dispersion algorithm;
- a quantization algorithm;
- an algorithm of equal separation of color space,
- an algorithm for image compression without a loss: a length coding algorithm, dictionary algorithms, the Hoffman statistical coding algorithm, an arithmetic coding algorithm;
- an algorithm of image compression with a loss: a JPEG compression algorithm, and a fractal compression algorithm.

In this paper, we will not dwell on the description of the mathematical component of each of the above methods due to the fact that the description of the algorithms of raster two-dimensional graphics and their software implementation are widely presented in educational and methodical literature. We make a point that the knowledge and ability to apply the algorithms and methods listed above is a prerequisite for the implementation of the fundamental training of future computer science teachers in computer graphics. The result of achieving a good mastery of these methods is to obtain the desired graphic image in one of the programming environments. The stages of solving these tasks using high-level programming languages are similar to those listed above.

Task 4.3. Visualization of geometric objects (parabola, hyperbola, ellipse, circle) using the tool "Spline"

Solution: When working with the Bézier curve tool, it is necessary to set the control points of the curve. When constructing a spline Bézier curve, the nodes and tangent vectors at the nodes are specified. In some graphics systems, a Bézier spline is also called a Bézier curve. The construction of a curve using the Bézier curve tool and a non-uniform rational basis spline (NURBS) is a sequence of work cycles affecting each of the curve nodes. The cycle begins by positioning the instrument pointer at a specific point and the subsequent location of the future node.

Briefly, the procedure for constructing a curvilinear segment includes the following steps:

1. Determine the position of the nodes and control vertices using the mouse cursor and by pressing the left mouse button.
2. Move the nodes or control vertices to set the desired curve shape.
3. Finish the drawing.
4. Save the result.

4.2. Three-dimensional task solution

The study of algorithms and methods of two-dimensional and three-dimensional graphics in the system of higher education in the CIS countries is carried out step by step from two-dimensional graphics to three-dimensional graphics.

An analysis of the content of modern courses related to computer graphics also shows that a number of modern algorithms and three-dimensional graphics methods are not included in this course content and, therefore, the range of tasks for the students to accomplish is rather narrow. To correct this, it is necessary for students to study the following algorithms and methods of creating three-dimensional graphics:

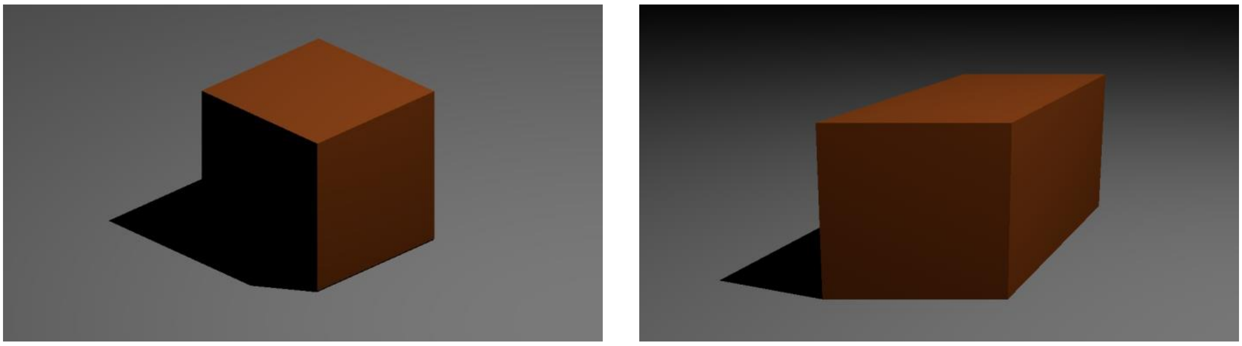
- hidden surface and hidden line removal algorithms: the re-bounded type method, the Z-buffer method, the removal of non-facial boundaries of a polyhedron, the Roberts algorithm, the Warnok algorithm, and the Weiler-Azerton algorithm;
- an algorithm for the line-by-line scanning for curvilinear surfaces, and an algorithm for the binary partitioning of space;
- priority methods: the artist method and the floating horizon method;
- scanline algorithms for curved surfaces;
- a method for the binary partitioning of space;
- an algorithm for determining the visible surfaces using ray tracing;
- lighting algorithms: the Gouraud, Blinn-Phong, and Cook-Torrens shading models; and
- the radiosity method.

These algorithms and methods of three-dimensional graphics are also studied in detail in computer graphics courses and are described in detail in educational and methodical literature; therefore, we will not discuss them here.

Let us consider an example of solving a three-dimensional task.

Task 4.4. Modeling an image of a cube

Solution: there are several algorithms used for removing invisible parts of an object. Among them are the painter's algorithm and the Z-buffer algorithm. We will restrict ourselves to the simple case of image construction of a cube. A cube is useful for analysis because it consists of six square faces. In computer graphics, even complex surfaces are replaced by similar surfaces assembled from flat polygonal faces. Let's assume that each face of the cube contains five "reference" points, four vertices and the center. At the central point, we will construct a normal line which is perpendicular to the surface. If we assume that the normal line (in our case) is directed from the object, then in the view coordinate system the projection of the normal line is on the z axis, which we will consider is going on the plane of the screen and the observer; it will be positive in the case when the face is visible to the observer, and negative if it is not visible. So we get a fairly simple algorithm for determining the visible and invisible faces. This algorithm can be applied in a general case, the case of a surface assembled from polygons. In order to construct a normal line it is necessary to make an assumption: if we assume that two sides of the polygon coming from one common vertex are vectors, then their vector product can be taken as a normal line to the surface of this polygon. The direction of the normal line will be uniquely determined if the order of vector factors is given.



(a) Isometric projection. (b) Oblique projection.

Fig. 3. Three-dimensional modeling of a cube using a visual programming environment

Computer graphics, by its definition, are used in important aspects of modern society such as 3D printers, 3D printing and 3D modeling, and it would be natural that these concepts and basic skills are formed in this area, and also that future computer science teachers' knowledge is deepened and their skills developed at a highly professional level (Nazarbayev, 2018). Therefore, speaking of content revision of the educational program in computer graphics in schools and in institutions of higher education, it is necessary to pay attention to the study these issues, which are becoming fundamental. In some schools there are pilot projects teaching three-dimensional graphics; the latest changes in the content of teaching computer science in the Nazarbayev Intellectual School now touches on the teaching of 3D modeling.

3D modeling is a process of developing a mathematical representation of any three-dimensional surface of an object using specialized software. The modern software market offers a wide range of graphics programs for drawing and modeling.

Today, the following 3D modeling tools are widely accepted (Farin, 2002):

- spline modeling: the Bézier curve, *B*-spline and NURBS (Piegl et al., 2012);
- polygon modeling: polygon mesh, tessellation method;
- using surface subdivisions; and
- procedural modeling.

Three-dimensional graphics include a set of methods and tools that allow the creation of three-dimensional objects using free-form surfaces, polygon meshes and primitive solids. Examples of such objects include the objects of the construction industry, the gaming industry, and printing. Building a geometrical projection of a three-dimensional model is carried out with the help of specialized graphics programs. The model created in these environments simulates the corresponding objects in the real world. Three-dimensional graphics deal with the representation of a three-dimensional object on a two-dimensional plane, hence a number of difficult mathematical transformations are needed to build a realistic model. Here are the main stages of building a 3D model:

1. Creating a reference (drawing the sketch of an original modeling object).
2. Geometric modeling (based on the reference).
3. Create a sweep.
4. Render the texture.
5. Adjust the texture, refraction, reflection and transparency.
6. Compare the resulting model with the original reference.

3D modeling implies the presence of several 3D models on a three-dimensional scene, which significantly complicates the process of modeling in a particular task. Next, we highlight the main stages of 3D modeling:

1. Modeling (creating a three-dimensional mathematical model of the scene, creating 3D-models).
2. Texturing (defining surface texture models).
3. Lighting (choice of light source).
4. Animation (movement of models).
5. Dynamic simulation (calculation of model interaction).
6. Rendering (visualizing models, building a model projection).
7. Compositing (model layout, refinement).

Determining the surfaces of a 3D texture model is not an easy task. The following algorithms are used to accomplish it:

- texture filtering algorithm;
- mipmapping;
- algorithm of point texturing;
- bilinear filtering algorithm;
- trilinear filtering algorithm; and
- anisotropic filtering algorithm.

Quite a complex mathematical calculation requires the stage of visualization (rendering), as at this stage there is a transformation of three-dimensional vector model to two-dimensional raster model. The following rendering algorithms are used:

- Z-buffer algorithm;
- scanline algorithm;
- ray tracing algorithm; and
- global illumination algorithm.

Static 3D models are of little interest; they become valuable in interaction with other models in the process of animation. Animation (in this case computer animation) is one of the most important stages of 3D modeling. Computer animation is produced by computer graphics methods and algorithms of raster and vector graphics, and two-dimensional and three-dimensional graphics.

2D animation allows the creation of moving objects or two-dimensional scenes. The previously reviewed Task 4.1 "Simulating a ball movement in a graphic screen" is a kind of example of programmable two-dimensional animation.

Below, we list the main steps of creating a computer animation:

- animation on key frames;
- recording (capturing) the movement;
- procedural animation;
- shape animation; and
- programmable animation.

From the point of view of the defining the essential training needed in computer graphics, the most interesting part of the course is the programmable animation, which is based on the algorithms of raster and vector graphics. The stages of creating a programmable animation are similar to the stages of creating two-dimensional and three-dimensional graphics using programming in high-level computer languages.

Let us now consider an example of a programmable animation.

Task 4.5. Animation of a rotating sphere

Solution: The illusion of a moving image is created by viewing a sequence of frames showing different phases of motion. To display a dynamic image, one must program the output of a sequence of frames. The frame rate should be fast enough to look realistic. This, in fact, is the main task in the programming of dynamic images. It is not easy to solve this task if each frame contains a complex image consisting of a large number of graphic elements, and even its own attributes, such as lighting conditions, the nature of the reflecting surface, etc.

The easiest way to include animation in a program is to simply redraw the graphic screen. This is the method used to solve the task. It displays images of a rotating a wireframe model of the sphere on the screen. For this purpose, two types of data are entered, the first one is for the storage of the world coordinates of a point, and the second is for the screen coordinates. The array contains the world coordinates of the points intersection of the “meridians” and “parallels” of the sphere. In addition, a supportive procedure for converting spherical coordinates into rectangular coordinates is used. We have already used the spherical coordinate system; in it, the position of a point is set by the length of the radius vector and two angles. The procedures perform a rotation conversion at given angles around each of the x, y, and z axes. In the first case, the rotation is performed for a single point, and in the second case for the sphere as a whole (that is, for all its reference points). The next frame is then displayed on the screen, and at this time the next frame is built on the invisible page. Then the pages switch roles.

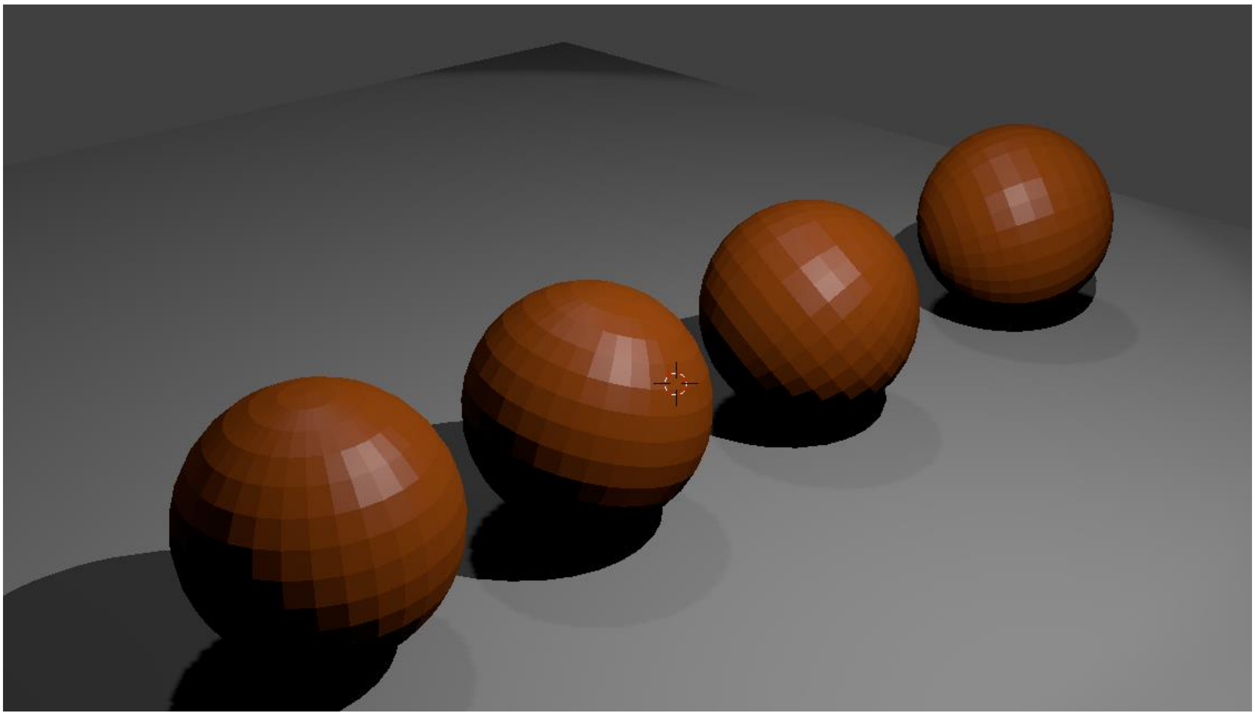


Fig. 4. Rotation of a sphere

3D animation allows the creation of 3D models and scenes. High-quality 3D animation allows viewers to visualize real objects and phenomena, and also nonexistent ones, to visually examine and understand complex processes. The scope of application of 3D modeling and animation covers almost all areas of work and is related to multimedia technology. At first glance, the list of stages of creating 3D animations looks quite simple, but each of them requires creative abilities and ideas from the animator-developer in addition to fundamental knowledge and the skills to program or work with animation software. We will list the stages of creating 3D-animation:

1. Developing creative ideas.
2. Writing a script and storyboard.
3. Creating 3D models.
4. Animating the 3D models.
5. Compositing or mixing frames into a single video clip.
6. Stacking the sound (voice overlay and voice acting).
7. Creating the titles.

The current process of three-dimensional modeling and animation is the culmination of the work in the field of computer graphics. It is quite complex and requires knowledge of the algorithms and methods that were discussed at the beginning of this section.

5. Methods for solving the tasks of developing pedagogical tools

Studying the practical experience of training future computer science teachers, as well as future subject teachers, in the field of information and communication technologies shows that such training is being carried out at all stages of the continuing education system in such disciplines as computer science, the increasing use of computers in education, digitalization of education, information and communication technologies in education, pedagogical technologies in education, informatization of education and learning problems. Within the framework of this training, the following pedagogical tasks are being completed (Koneva, 2008):

- The development of pedagogical tools using a text editor: using text editor capabilities to create forms, using text editor tables to create forms, preparing printed materials in a text editor, developing graphic elements in a text editor, preparing didactic materials in a text editor, creating printed advertising products in a text editor.
- The development of teaching tools using spreadsheets: the accounting of material and technical equipment in a spreadsheet, the development of an electronic journal in a spreadsheet, the automation of monitoring progress by using a spreadsheet, and the use of graphics in a spreadsheet.
- Creating pedagogical multimedia presentations: presentation of the curriculum, development of educational presentations, presentation of an almanac, and the development of the teacher's electronic portfolio of teaching aids.
- The preparation and development of pedagogical tools using a desktop publishing system: preparation of printed materials for extracurricular activities, the development of electronic educational materials with the help of a desktop publishing system.

Thus, it follows that a number of pedagogical tasks will require future teachers to know and understand the field of computer graphics. These tasks include:

- Tasks focused on the use of graphic capabilities of a text editor: the preparation of printed materials, development of graphic elements, preparation of didactic materials, and creating printed advertising materials.
- Tasks focused on the use of graphic capabilities of the table processor: a graphical representation of the results of monitoring performance, and the use of elements of business graphics.
- Tasks focused on the use of multimedia presentations: the presentation of the curriculum, and the development of educational presentations, a presentation of the almanac, and the development of an electronic portfolio of teaching aids.
- Tasks focused on the use of desktop publishing: the development of a teacher's electronic portfolio, the preparation of printed materials for extracurricular activities, and the development of an electronic syllabus.

Thus, at the end of postgraduate education, the future teacher of computer science should have the necessary knowledge, skills and abilities in the field of creating graphic objects in a text editor (images, diagrams, inscriptions), should be able to build charts and graphs in a spreadsheet, to create and use graphic elements for the monitoring and visual presentation of results, to design and create educational multimedia presentations, and prepare printed materials for extracurricular activities (Koneva et al., 2018).

An analysis of the professional activities of not only the future computer studies teacher, but also of teachers in general, in terms of his or her use of methods, technologies and information tools, reveals that the teacher in their daily pedagogical activities encounters visualization tools, and elements of a pedagogical experiment: self-analysis of a lesson, and a lesson on the same topic in different classes or groups conducted in different ways; an analysis of performance carried out by topic, section, class or group, terms or semesters, etc. Thus, the future teacher of computer studies should have the skills needed to conduct and analyze both research and experimental teaching activities, including a pedagogical experiment (Koneva et al., 2012).

The issues of training and organizing a pedagogical experiment are examined in pedagogy courses, information technologies in science and education, organizing and conducting pedagogical research; and, as a result, the knowledge and skills gained manifest themselves in the processes of pedagogical practice, research, and experimental pedagogical activities. But as education becomes more computerized, this knowledge alone is not enough. Knowledge is also required in from the following areas:

- information technologies: skills and abilities to use a text editor, spreadsheet, presentation development tools, etc.;

- the increased use of computers in education: methods of accessing, sharing and creating scientific and methodological research, and methods of computer-based control and measurement of learning outcomes.

But, unfortunately, for a competent presentation of the results of a teacher's research activity, including a computer science teacher, having a general knowledge and understanding of the concepts is not enough. It is also necessary to teach teachers how to accomplish the tasks of research and create experimental-pedagogical content. This includes the following tasks:

- presenting the results of research activities and pedagogical experiments with the help of a text editor using a text editor to prepare a publication, a research report, a dissertation, an abstract, and to work in teams on research using a text editor;
- processing the results of research activities and pedagogical experiments using spreadsheets: the automated monitoring of progress using a spreadsheet, processing the results of research and a pedagogical experiments, using elements of business graphics for a visual presentation of the research results in a spreadsheet.
- simulating the research activities results and pedagogical experiment with the help of multimedia presentations: Simulation of the research work plan in the form of a presentation, development of an electronic report in the form of multimedia presentation, simulation by a research almanac in the form of a presentation, creating an electronic portfolio based on the results of research and pedagogical experiment.
- preparing and simulation of the research work's results and pedagogical experiments with the help of a desktop publishing system: the development of the corporate style of a teacher-researcher, preparation of printed products of scientific content, and the development of an electronic resource based on the results of research activities and a pedagogical experiment.

Computer graphics as a field of computer science and information technology allows users to fully disclose the results of the tasks listed above.

From the computer graphics point of view, a text editor belongs to the desktop publishing system, it allows the user to prepare printed products such as a scientific article, scientific report, dissertation, and abstract. Actually, the desktop publishing system allows a researcher to convey information about their research and teaching activities in the form of a booklet, an abstract in the form of a brochure, or the development of an electronic resource based on the results of research work and pedagogical experiments.

The development of business graphics takes the automation of processing results of experimental and pedagogical work process to a higher level at all stages of the pedagogical experiment. The most optimal form of using graphics in these conditions is to depict the statistical data from ascertaining, testing and forming experiments, which are most easily analyzed, visualized and processed and thus allows viewers to see the dynamics of the experimental and control groups, and to conduct a comparative analysis of the results.

The effectiveness of such processes depends largely on how a future computer science teacher is able to use graphics tools to carry out the functions of statistical processing of experimental results, controls, and monitoring. The use of graphics creates conditions for more efficient analysis of research results using processes related to information processing. Processing the results of an experiment using graphics can significantly reduce the time and labor costs of analysis and pedagogical monitoring, and at the same time using graphics significantly increases the information content of the results. The graphics system allows viewers to observe the dynamics of information indicators. Results of the analysis of an experiment can be presented in the form of tables, graphs and charts. Charts, and in particular graphs, are elements of business graphics. Almost all modern spreadsheets, word processors, and presentation development tools have built-in business graphics. To produce these types of graphics, there is a graphical mode in which you can build charts of different types, which shows numerical dependencies.

It is known that graphs and charts do not just appear by themselves; they should be based on numerical data. In a pedagogical experiment, such data is the data of pedagogical monitoring. The effectiveness of a teacher's assessment and evaluation activities depends largely on how well he or she implements all the basic functions of monitoring each student's learning results, and how well the teacher is able to use information technology tools to perform the functions of control and monitoring.

The information control function is a systematic recording of learning results, which allows one to judge the performance of each student and his or her achievements and shortcomings in their educational work, which is very important at the evaluation stage.

The control adjusting function provides feedback between the teacher and student, which is necessary to for the teacher to make adjustments to the teaching methodology used, and in the further course of pedagogical experimental work, the control function can affect the redistribution of educational time between the various issues of the topic caused by the student's deficiencies in knowledge, which is important at the stage of verifying the experiment.

And finally, it is very important for teachers to be able to competently present the results of their research and teaching activities and to show the results of their experimental work; it must be clear to everyone what the researcher was doing, what was researched, how, and what the results were . Also, no one wants to listen to long speeches or try to memorize numbers given in an oral presentation. Therefore, an electronic report should be presented, which will combine both the elements of an abstract and the results of the pedagogical monitoring and allow everything to be presented clearly and concisely.

Let us now consider in detail an example of automating the monitoring of student progress using graphics tools.

Task 5: Construction of an attendance report and the students' progress on a specific topic on a particular subject using graphics elements (histogram, schedule)

Solution:

1. Make the necessary calculations. For example, you can insert Microsoft Excel's SUM or AVERAGE function, or even develop your own functions.

2. Select the information you need to create a schedule. If you want to select information that is not in adjacent cells, select one group of cells, hold down the Ctrl key, and then select another group of cells.

3. Create a histogram with a series of columns. To create graphs, you need to launch the diagram wizard, which will help you to select the type of graph, give the name of the graph, label the axes, specify the data on the diagram, etc. Use the title of the table as the title of the graph. If desired, enter titles for the x and y axes. Save the graph as a new sheet. Remove excess information. If necessary, refer to the section How to create a bar chart or histogram for a comparison of values and values of the program's reference guide.

4. Copy the sheet with the histogram. Move the copied graph to the end of the document.

5. Return to the second graph in the editing table and convert it to a graph with icons, formatting the columns with the image you copied. If you use OpenOffice Calc, format the columns with pre-rendered graphics.

6. Rename all the tables and graphs and delete unnecessary sheets.

7. Arrange the sheets in such a way that the first is a table, then a histogram, and then a graph with icons.

8. Save your work.

Thus, to organize and conduct research and experimental-pedagogical activity, the teacher-researcher must possess the knowledge, skills and abilities to provide reports in the form of articles, reports, scientific reports, theses and other documentation in a word processor for performing the statistical processing of scientific and pedagogical information and to demonstrate the results of an experiment in the form of a report and/or presentation.

The main requirements for a future computer science teacher to organize and conduct a pedagogical experiment are the knowledge and skills to work with printed materials, use of graphics for pedagogical monitoring and proof of the pedagogical research hypothesis, and to be able to create pedagogical multimedia presentations.

Therefore, the priority areas for teaching computer graphics to future computer science teachers are the creation of printed materials, graphics, and multimedia presentations.

6. Conclusion

In the context of teaching fundamental computer graphics to future teachers, the algorithms and procedures needed for solving graphic tasks are not limited to the examples listed above. It is clear that computer science teachers must have the requisite knowledge and understanding of fundamental approaches to the methods of solving computer graphics tasks. This will contribute not only to the teacher's professional ability and efficacy despite the constant improvements to computer technology, but also to the teacher's ability to teach using the latest technical tools and techniques. This knowledge will further develop a teacher's interest and desire to prepare young members of society who will live and work in constantly changing conditions.

By increasing computer science teachers' fundamental knowledge and understanding of computer graphics, the students' related studies of computational geometry, drawing, and computer graphics will allow students to create and evaluate images of various graphic objects.

After analyzing different methods of solving tasks in computer graphics and defining the principles of their classification, we can conclude the following: the systematization of tasks in computer graphics makes it possible to effectively and correctly use different methods of solving tasks at different stages of the educational process, and to develop the students' abilities to work with computer graphics tools of different levels, and to create conditions that motivate and sustain the students' interest in computer graphics, thus enhancing their independent computer activities and improving the quality of graphics training in the context of fundamental computer science education. The future computer science teacher needs to be competent in the field of information and communication technology, in working with graphic editors, in demonstrating algorithms of raster and vector graphics, in using the technical language of computer science, and in working out the methodology for choosing and using knowledge and skills in their future professional activities.

The proposals described to improve fundamental training of computer science teachers are not limited to the improvement of the disciplines mentioned above. Of course, the main aspects of improving the fundamental training of teachers in higher education institutions are reflected in other courses of the curriculum for training future teachers of computer science.

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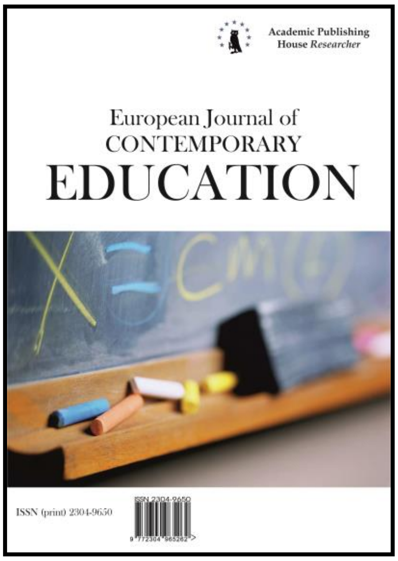

The Applicability of Visualization Tools in the Meta-Design of an Educational Environment

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Abstract

At the stage of designing an educational environment, one of the most significant problems is the creation of effective visualization tools for collecting, organizing and analysing educational information. Existing approaches to visual information analysis have a number of disadvantages, which include a significant resource intensity and high requirements for preparation for those who are involved in the analysis. This article demonstrates the feasibility of using visualization tools for the design assessment of educational environments, which enables the development of necessary tools for tasks with a large amount of educational information, as well as in the event of their change or accumulation. The purposeful use of visual perception features and the proposed approach to the organization of educational activities create perspectives for visualization tools, while working with a large amount of information. A number of features of a student and educational environment interaction have been identified, which are designed according to the principle of meta-design.

Keywords: visual information, visual analysis effectiveness, perception, meta-design, educational environment.

1. Introduction

The general direction of information and network technologies development runs parallel with user involvement in active cooperation. The Internet is a platform on which people can not only receive information, read news, and listen to the radio, but also self-educate and collaborate with another people. Such a model of activity is being implemented today in areas such as management, business, education, marketing and trade. There are no obstacles left to obtaining the

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necessary skills and tools for creating visual, musical, interactive or educational content. Restrictions on distributing new content to an interested audience are quickly disappearing. The educational environment is becoming increasingly accessible, and the only thing that is required nowadays from a person is the desire to learn and create.

The inclusion of a student in constructive activities, when he or she uses not only prepared educational resources, but also actively participates in their development, ensures the task is appropriate to his needs and learning environment creation. However, an increase in volume of information, including collecting processes, systematizing processes, information processing and analysing and, accordingly, the information equipment a person possesses, confronts developers with the problem of creating tools that can increase the speed of educational material assimilation. Thus, in the last decade there has been a transition from educational environment design to meta-design.

2. Discussion

Definition of educational environment metadata

The philosophy of "pedagogy of social constructionism", which unites the ideas of constructivism and social constructionism and was developed by the work of L.S. Vygotsky, D. Dewey, J. Piaget, E. Glasersfeld (Vygotskij, 1991; Piazhe, 2003; Glasersfeld, 1978) is expedient for developing a learning environment by the principle of meta-design. These directions show the main ideas and principles of humanistic pedagogy, which were developed by people, as mentioned above and also by S.L. Rubenshneyn, K. Rogers et al (Roghers, 1994; Rubinshtejn, 2002). The student's cognitive activity, his personality, abilities, intellect, features of development and perception are at the centre of the educational process developed by this approach. In this context, a teacher acquires a new status – that of a designer, a mentor, an organizer and a partner in the trainee's cognitive activity. At the same time, previously dominant interaction models, which featured a strong separation of "designers" and "users", are transformed into a model of cooperation: "designer-teacher" and "co-designer-student". Thus, meta-design (Fischer et al., 2006) is an evolving approach that uses information technology to promote education and development as support for collaboration and communication.

Within the framework of humanistic pedagogy, an educational process is considered a trilateral active one: the teaching subject is active, the learning subject is active and the environment between them is active (Vygotskij, 1991; Hutorskoj, 2008). Such a process assumes that by interacting with an environment, a person develops himself and changes the environment. One of the advantages of meta-design is that the basis of any learning is an interpretation of received information through the prism of previously acquired knowledge. This means that learning is much more effective if a student creates something for others, and conveys his knowledge and experience. A person is not considered as a product of an environment and an idea of personality is formed, as a product of human interaction with an environment.

In the pedagogical context, modern meta-design involves educational activities' planning in such a way that students can not only be passive readers and viewers, but also active content creators. Because of the students' directed actions, an environment should be created in which users can implement their own digital histories and models and, based on these, form unique teaching content. Meta-design social aspect expands this definition to the level of interaction in groups. Meta-design development makes it necessary to formulate and to substantiate fundamental laws that characterize students' interaction with the reality full of information.

Problems of learning environment formation

The concept of a "learning environment" in pedagogical science shows the interconnection of conditions which ensure human development (Vygotskij, 1991; Hutorskoj, 2008; Averchenkov et al., 2015). The learning environment acts as a dynamic system, which is an integral set of educational situations that progressively replace each other. A system of psychological, pedagogical and didactic conditions and stimuli arises, which puts a person in front of necessity of a conscious choice, adjustment, formation and implementation of his own learning model, that means independent educational activities' implementation.

Issues of learning environment organizing, of creating an environment and tools that consider the individual characteristics of a student, and of multi-channel and multi-sensory perception, become relevant for organizing a sequence of educational situations characterized by high efficiency. Educational process effectiveness, in this case, is the formation speed of the system of knowledge necessary for a student.

Educational environment formation occurs sequentially in stages, through the accumulation, synthesis and systematization of educational information. This allows the accumulated resources to be used not only for those who participate in its creation, but also to further students. A teacher, while developing a learning environment, is a moderator and a mentor who creates analysis and the communication tools necessary for the integration and adaptation of educational material. To make a student an active participant in the educational process, it is necessary to have tools that will allow an educational trajectory to be formed independently and its effectiveness to be evaluated.

The problem of the selection and analysis of available information is a modern and relevant one. Not all available data is valuable – according to the IDC, by 2020 useful information will make up only 35 % of all generated information (BigData, 2013). Accumulated educational information is poorly structured and not fully utilized. Therefore, there is a need to use such tools that will allow the collection, systematization and analysis of educational information with high efficiency. One of the perspective areas in the development of operational information analysis tools is specialized visual analytics tools' development, which purposefully takes advantage of visual perception.

The multisensory approach means learning based on the perception channels of all senses: hearing, sight, touch and smell, which makes new material perception and memorizing easier (Gardner, 1993). While creating meta design tools, it is advisable to focus on visual perception, which is dominant for most students. Strengthening the perception of the visual channel is one of the possible implementations of the multisensory approach in meta-design.

This theory has great significance for pedagogical science in general, and for the presented work. This statement originates from the results of the research conducted by the authors to solve the problem of creating educational information visualization tools aimed at increasing selection effectiveness and speed, educational information systematization and assimilation.

Visualization of information

In the case of the traditional approach to attracting visualization capabilities, the task of interpreting visualized data could be solved only in exceptional cases, characterized by high level formalization and by experience in studying similar issues. A possible direction for visual analytics development is the creation of visualization tools that use the cognitive potential of interpreting dynamic images (Shklyar, 2016). In this case, dynamic means not only informative characteristics, containing information depending on time, but also any values whose interpretation is carried out by comparing different values. Existing visual analytics creation approaches mostly do not use the visual perception features of changing visual images, which significantly differ from the observation of static images, and could become the basis for increasing the effectiveness of educational information usage.

A practical study of visualization capabilities in meta design is associated with the need to match visual analytics with scalability requirements. The reason for this is the widespread need to reformulate an existing task of researching data into an individual version of studying only a fragment of data or, even more difficult, into a version with data accumulation. Visualization usage as an analytical tool offers a natural solution to this problem; for example, through the use of targeted visual perception features, providing a simultaneous holistic perception of information related to different objects, but combined in a visual field into a generalized informative image (North, 2006).

Visualization tools effectiveness

The comparison of visual analytics opportunities with other approaches implies the existence of a quantitative measure that allows a conclusion to be made in favour of one of the compared options. The duration of procedures, which exist while developing or using visualization tools, might be the simplest numerical evaluation. However, the need for a high level of processing, transfer, accumulation, and usage of educational information processes formalization is an obstacle hindering the development of this approach.

The effectiveness of meta-design processes can be assessed by the amount of resources necessary for solving an educational problem. Based on this, and considering the diversity of efforts involved in data analysis, the importance of different types of used resources and their interchangeability have a valuable meaning (Sacha et al., 2014). To determine the effectiveness, along with the main types of resources – time and computing resources – It becomes relevant to consider efforts made by a person or a group of people to achieve the goal, including intellectual, physical or emotional efforts.

A visual data model

The model M in metadata D (a visual data model) is an object of visual perception (image), which is associated with this data according to the predefined rule F, i.e. M = F (D). Accordingly, the rule F, formulated on the basis of a number of additional factors, makes it possible to determine data visual image properties and is defined as a visual presentation function. Defined in this way, function F is a mean of influencing meta-design effectiveness and should be determined based on the need of its increase. The choice of the visual presentation function depends on data D properties, presented in an educational environment, in time constraints of an educational process and in users' characteristics $U = \{U_1 .. U_n\}$, which are essential for achieving educational processes goals.

Semantic interaction

The increase in the amount of data, which exists in an educational environment, is a characteristic feature of meta-design. One complication is that data models used for their analysis, selection or use have a natural limit, the excess of which renders previously developed means of interaction with information useless. A perspective direction could be the organization of cognitive and computational resources sharing (Endert et al., 2014). The advantage of systems focused on semantic interaction implementation is the adaptation of the data visual presentation function to the mental analytical structures of an observer. This allows for the combination of student's visualization metaphors and associative patterns, which creates conditions for reducing a visual model's complexity.

Visual analytics development in this direction necessitates the existence of a detailed understanding of functioning patterns of human thinking, which interpret visual information. In this case, it is necessary to move away from the model of cognition as a "black box" which receives perceptual data, and where knowledge integrated into an existing system of human concepts is formed at the output (Chen, 2008). Thus, one of the actual tasks of meta-design is the study of multisensory information interpretation principles, especially its visual component.

Perception principles

Perception is a process that provides individual communication with external information sources. In addition, perception could be defined as the result of the direct effects of objects or phenomena on sense organs (Wijk, 2005), which act as information external sources analysers. Among the existing types of analysers responsible for vision – hearing, touch, smell, taste and kinaesthesia – the visual channel is the most informative and loaded one.

External objects' images that appear as a result of perception are a subjective form that includes, in addition to data from analysers, aspects of an individual attitude to an object: interest, motivation and emotional evaluation (Mazza, 2009). The possible influence of subjective factors on the image of an external object leads to the variability of this image in time or to a fundamentally new result of revaluation. Thus, visual models' interpretation by a student (user), aimed at understanding their meaning, as well as at extracting new knowledge, depends on both the visual image objective characteristics and individual characteristics.

Visual perception is one of the perception types in general and has a number of common characteristics. Generalization, objectivity, integrity and constancy of perception should be referred to as essential for substantiating visualization possibilities. The reasonable management of the created visual image properties, considering the characteristics mentioned above, enables visualization interpretability to be controlled. Thus, the reasonable usage of perception subjective aspects creates conditions for increasing the effectiveness of meta-design processes.

Visual examination time

The value of K_A is the amount of new information received by a user while searching and formulating an answer to his existing question using visual data models. New information is the result of the user's interaction with the visual data model, i.e. the message received for a limited time T_A.

$$K_A = \int_0^{T_A} P(I, K, t)dt = K_A(T_A),$$

where P (I, K, t) — is the function of visual perception, K — is the amount of user's knowledge, and I is the perceived image, which is a visual data model. The visual perception function P is considered bounded, piecewise continuous and increasing.

The value of $K_A(T_A)$ could be defined as the cognitive (informative) value of the visualization interpretation process and, accordingly, T_A is studying time, i.e. the time interval spent by a user to achieve the goal of the study. Therefore, an inverse relationship could be defined for time T_A spent on achieving the solution:

$$T_A = T_A (P, K_0, S),$$

associating solving time T_A with the task complexity K *, the initial amount of user's knowledge K_0, the process of interpreting P (I, K), and the visual presentation function S = S (t). Thus, a quantitative measure, which allows the visual model's capabilities to be evaluated, might involve an analysis of time T_A, which depends on the task for which solving the visual model would be used, as well as depending on the capabilities of a particular user.

Quantitative assessment of information in a received message, if it is even plain text, is a task that can be solved differently. It is necessary to take into account the fact that the sequence of measured information units that make a message do not determine its overall information value, since for a recipient of a message, this value is subjective (Cui et al., 2007). Therefore, determining the analysis time as a measure of visualization effectiveness allows the problem of measuring the visualization informative value while choosing a visual presentation function to be circumvented.

10. Experimental evaluation of visualization tools' effectiveness

Based on the introduced definitions, the visual interpretation processes effectiveness – which is the basis of meta-design – and a time-dependent value, the main task for data visualization tool developers is to reduce the time spent at any stage of interaction with educational information (Shklyar et al., 2018). Thus, in order to assess visualization tools' effectiveness in educational meta-design, it is necessary to have an idea of the dependence of research time on any factors that have a significant impact on it.

To obtain data which will allow the merits of a particular visual presentation function to be evaluated, the methodology for conducting test solutions has been developed. The proposed technique is about conducting a series of solutions for test problems, characterized by a number of controlled constraints, and measuring time intervals corresponding to the stages of the user's interaction with the visual model. The user's interaction with the model, in this case, implies any operations available to a user, with the exception of changing the visual presentation function and the set of visualized data (Figure 1).

A test solution involves creating a visual data model using the predefined visual presentation function. A user is allowed to formulate an unlimited number of hypotheses for answering the question; each hypothesis is considered to be the next step of the analysis. The formulation of the correct hypothesis means the completion of a problem's solution. Measurements of time intervals spent by a user on the formation of each new hypothesis showed the presence of characteristic stages of deceleration and acceleration during the solving of the analysis problem for the majority of test measurements.

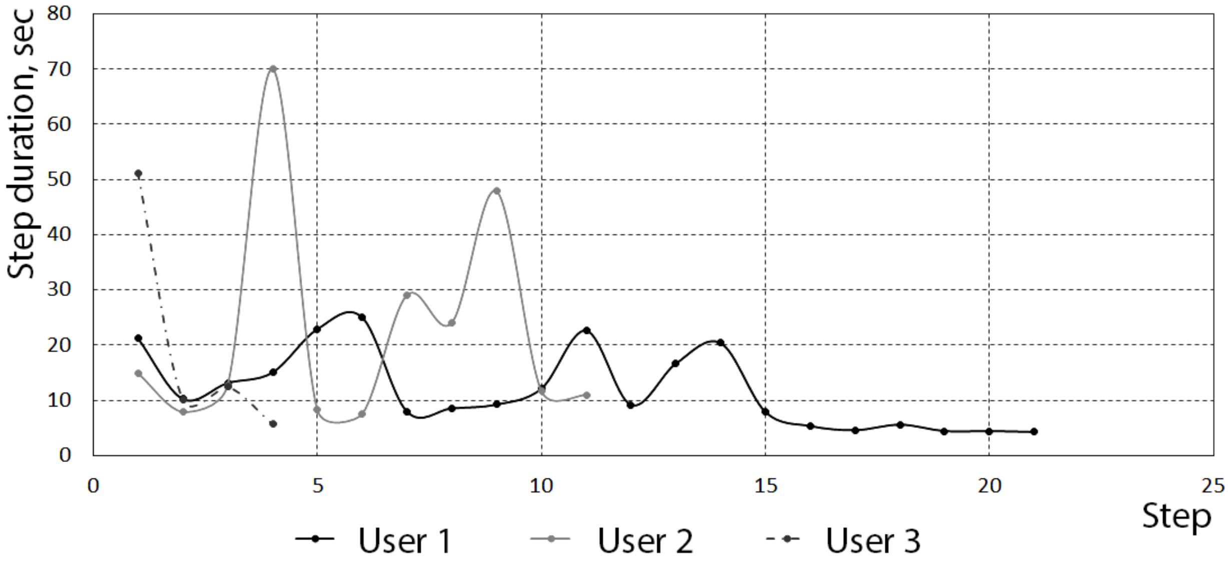

Fig. 1. An example of periodic change in visualization interpretation speed

The stages of the user's interaction with the visual model, during which the time spent on the next decision hypothesis formation is constantly reduced, could be interpreted as "learning" intervals. The reason for this is the time reduction taken to make a new decision if the previous hypothesis is erroneous. Thus, there is an accumulation of new information that is a consequence of the verification of hypotheses proposed by a user (Pirolli et al., 2005). Changing the level of awareness of the K user leads to a reduction in time for building a new hypothesis; however, after the accumulation of new information, as was demonstrated by the results of the studies, the next stage is rethinking, characterized by a significant slowdown in the process of building a new hypothesis (Figure 2).

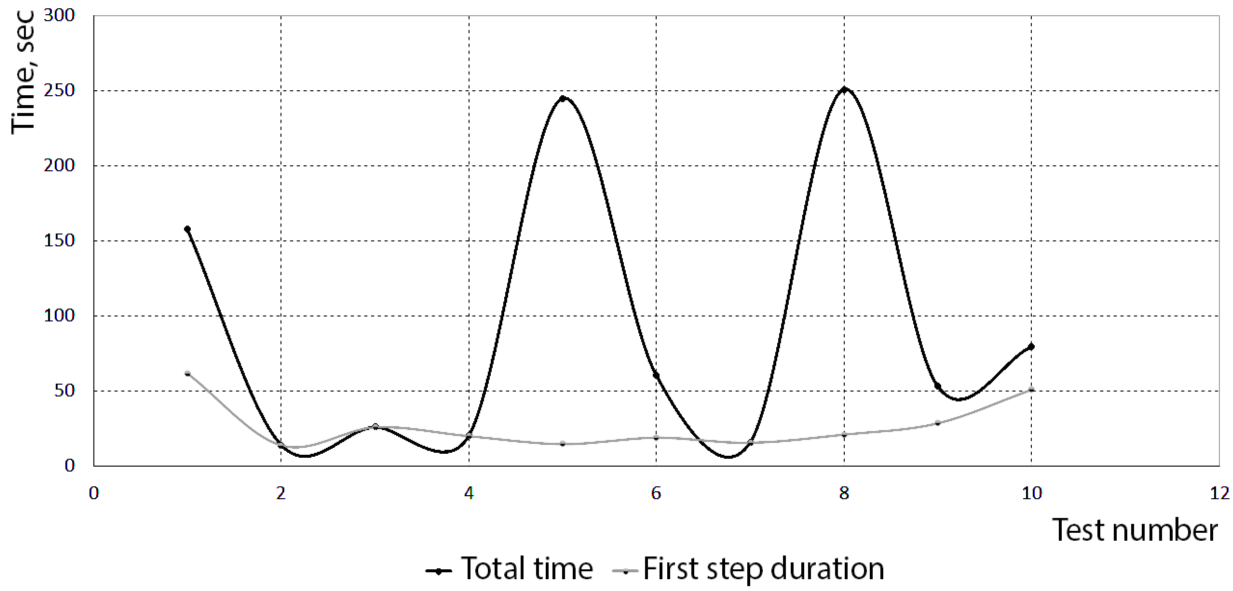

Fig. 2. A change in decision time for different presentation functions

The first stage has a particular importance in this case, which is characterized by an increase in a user's thinking speed, which is presented in most of the test measurements. Unlike the subsequent similar stages, during the first stage, a user is familiarized with the data image and with the visual presentation function features. This assertion is supported by the abbreviation of this stage when a user re-uses the same visual presentation function. Thus, the obtained experimental data could be used to determine the estimated values of learning intervals and information interpretation for the corresponding visual presentation function (Chen, 2005).

Visual model example

In an educational environment that uses meta-design principles, students participate in the systematization and analysis of educational information. The results of this activity are information visual models, the sources of which is also independent research. Models (images of information) are prepared for quick perception, with the possibility of using this model by other participants. As a practical example, the visual model has been proposed, which was used to evaluate student projects (Figure 3) (Shklyar et al., 2017).

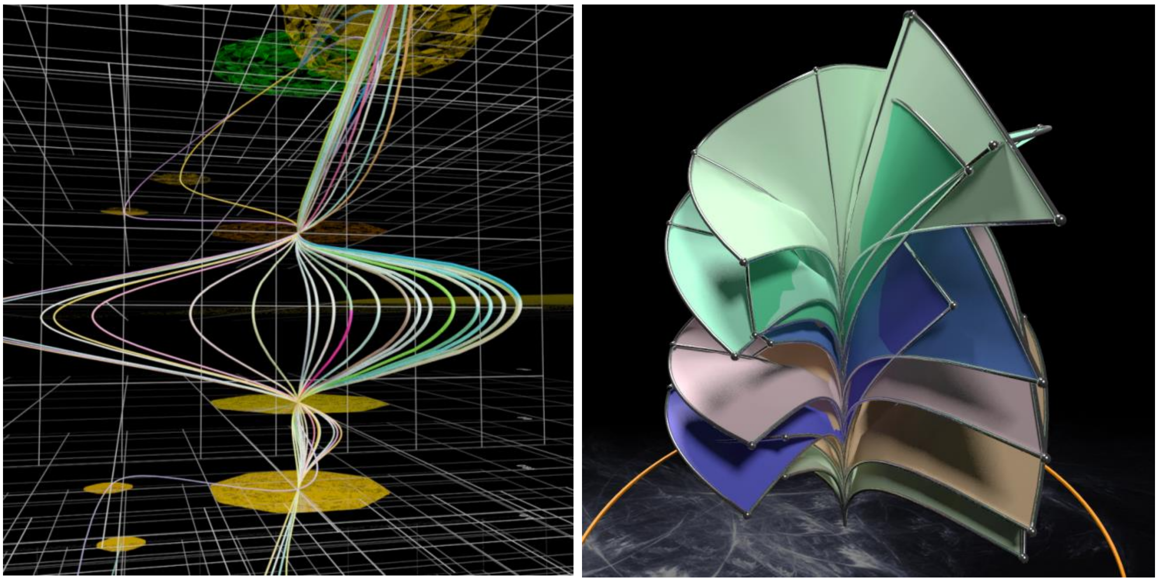

Fig. 3. Model of student projects evaluation

Informative objects that create a volume of visualized information are multi-criteria evaluations of the results of students' project activities. The developed model is a set of horizontal planes, each of which combines data which belongs to a separate property of informative objects. The plane is defined by two orthogonal scales. The main scale represents the nominal values of an individual property. The additional orthogonal scale is used for a visual comparison of objects with each other. Points of different planes that display properties of a single object are combined into a single image of this object, creating a unique visual image that is prepared for comparative analysis. The order of properties' images arrangement relative to each other is used as an independent scale, which shows significant degrees of the selected property for the analysis (Shklyar, 2016).

Based on the study results of visual perception potential in the interpretation of data patterns, the conclusion is that the use of specialized visualization tools in the meta-design of the learning environment is a perspective field. This allows students to increase effectiveness and selection speed, systematization and assimilation of educational information. Simultaneously with the use of visual content by students, a teacher is able to use the same visualization tools as active tools for updating content, as well as for analysing and interpreting the results of students' work in an educational environment.

3. Conclusion

In this article, a method was proposed for evaluating the feasibility of using visualization tools for meta-design, which allows the necessary tools to be developed for tasks that are characterized by the presence of a large amount of educational information, as well as in case of its modification or accumulation. Usage of the proposed method enables a learning environment to be built with the opportunity of benefits maximization for students. This will create a unified and interrelated environment for use in pedagogy, applicable to a wide and diverse range of educational purposes.

Experimental studies revealed a number of features of interactions between a student and an educational environment, designed according to the principle of meta-design. The purposeful use of visual perception features and the proposed approach to educational activities creates a perspective to use visualization tools while working with a large amount of educational information.

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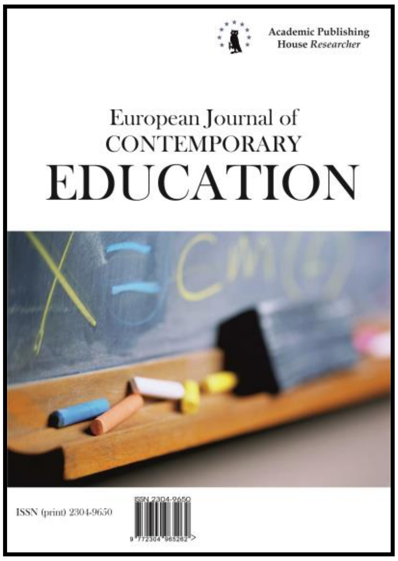

Visualisation as a Method for the Development of the Term Rectangle for Pupils in Primary School

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Abstract

Visualisation is an important part of the cognitive process in mathematics. Pedagogical-psychological theoretical frameworks concerning cognitive processes consider perception and visualisation as basic conditions for the creation of correct mental imagery. This study examined visualisation as a key factor in the development of geometric concepts for pupils in primary and lower secondary education. The study has empirical-applicational characteristics. The results of research on Slovakian students regarding geometric concepts about rectangles and squares are described. The research sample consisted of two groups of pupils in the 4th grade (primary level) and 9th grade (lower secondary level). The comparison of results between the two groups enabled the identification of several misconceptions made by pupils regarding rectangles and several suggestions are included for educational interventions based on static and dynamic visualisation models.

Keywords: visualisation, pupils, primary school, results.

1. Introduction

The visualisation of geometric terms and procedures is an important element in the process of creation of geometric conceptions. Basic pedagogical and psychological cognitive models, which have been enhanced to provide descriptions of cognitive processes in mathematics or geometry, indicate the relevance of visualisation processes. Based on the results of the present study on the geometrical conceptions of Slovakian pupils in the 4th grade of primary school and the 9th grade, and their comparison, we identified the most frequent misconceptions regarding planar shapes. On-going misconceptions were found in themes regarding rectangles, squares and their properties. Thus, in this study, real and virtual education models that have the potential to create desirable conditions for the creation of tangible conceptions or for the correction of misconceptions of geometric terms and their properties were established (see also Žilková et al., 2018).

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2. Discussion

Theoretical framework: visualisation as a component of the cognitive process

The meaning of visualisation in the cognitive process is supported by many educational and psychological theories. In the following section, several examples of cognitive theories are presented. Visualisation plays an important role in these theories in the field of cognitive processes.

Swiss psychologist Jean Piaget (1896–1980) studied the cognitive development of children and examined the process of creation of their mental models. Piaget's concept of cognitive development of a child defines four stages that bond to the biological development of a child (McLeod, 2018): sensorimotor stage (birth to age 2), pre-operational stage (from age 2 to age 7), concrete operational stage (from age 7 to age 11) and formal operational stage (age 11+). Piaget and Inhelder (2010) studied the creation of figurative thoughts and compared their qualities at the pre-operational and operational levels. They distinguished between two types of figurative thoughts: reproductive imagery—imagery of known and earlier observed events, and anticipatory imagery—imagery that illustrates movements or transformation. They found that on a pre-operational level only static figurative imageries are present. Thus, children are able to create anticipatory imagery only after they reach the level of real operations (approximately from 7 years of age). Therefore, if we expect from a child an imagery of movement or some transformation, then this process requires imageries of anticipatory character.

If we want to reflect the results of Piaget and Inhelder's (2010) research to the teaching of geometry, it is necessary to create educational interventions in which conditions for the creation of static figurative imagery are made first and only then the activities can be expanded to examine the dynamic models of geometric terms and procedures. For example, the examination of static models and non-models of squares (e.g. pictures of shapes, puzzles, creation of models of squares in a square grid, geoboard or with the use of sticks, folding and cutting paper and so on) must be made before the creation of mental models regarding the geometric term 'square'. Thus, children gain experiences on which shape is and which shape is not a square. Several software programs of dynamic geometry (e.g. GeoGebra) may be appropriate environments for the creation and examination of dynamic models of squares. Within these educational software programs, it is possible to visualise the dynamic and transformation processes that are difficult to realise with static models. Thus, software programs can support the creation of anticipatory imagery in cases where a child is not able to mentally manipulate geometrical imagery.

American psychologist Jerome Seymour Bruner (1915–2016) studied cognitive processes from the point of view of intellectual development. Within his cognitive model, Bruner (1966) suggested the application of the following three types of representations: ***enactive representations, iconic representations and symbolic representations***. Enactive representations are principally based on perception, which means manipulation with concrete objects. Iconic representations assume working with imagery of mental thoughts that a child has already encountered. The highest level of abstraction is symbolic representations in which the ability to describe terms based on valid professional terminology is assumed and imageries are qualitatively on a higher level. Bruner's (1966) theory is effective when we proceed from enactive through iconic to symbolic representations in education. Bruner's (1966) theory states that the creation of a child's conception is conditioned by education and the influence of adults where it is necessary to use the correct type of representation. What then are the educational implications for geometric education in the context of Bruner's (1966) theory? It is evident that the visualisation of geometric terms with the use of enactive and iconic representations determines the creation of correct geometric conceptions. If a geometry teacher accepts the biological and cognitive development of each child individually, then he/she creates conditions for the creation of correct abstract conceptions regarding geometric terms. If some of the stated conditions are not reflected in the educational process, then misconceptions about geometric terms might be created that become obstructions to further geometrical recognition (Žilková, 2017).

The cognitive process in mathematics and its specifics were elaborated by Hejný (2014) and named the 'Theory of generic model' (TGM). TGM consists of five stages (***motivation, isolated models, generic modes, abstract cognition and crystallisation***) and two cognitive transformations (***process of generalisation and process of abstraction***). The term 'generic model' encorporates the entire set of different isolated models. Hejný's (2014) theory reflects the cognitive process stages in mathematics but also accentuates the importance of many different experiences. The specification of geometric terms is also based first on manipulation with concrete models and non-models of geometric terms creating conditions for the creation of abstract representation of terms (generic model) later on. For a child, the generic model is also a concrete representative of a certain group of isolated models. Abstract conceptions about geometric terms are no longer connected with a concrete model but integrate all important elements and properties of a given term. Thus, visualisation is more a representation of the stages of motivation, isolated models and generic models within TGM.

Teachers working in the school environment seldom use interactive approaches during the introduction of geometric notions. Haptic and virtual manipulation can help pupils understand these geometric notions. Manipulative activities are oriented towards giving pupils experience with several selected plane shapes in different positions and different magnitudes. It is important that the personal and figural concepts (Fischbein, 1993) are not connected to only one model of a particular shape (for example in the standard size).

One of the best known theories regarding the development of geometric terms is the van Hiele model of geometric thinking. Pierre van Hiele (1986, 1999) observed and defined five different levels of geometric thinking of individuals: ***visualisation, analysis, abstraction, deduction and rigour***. Each level has its own characteristic expressions based on those that can identify the level of geometric thinking of a child. The van Hiele theory has been validated in previous studies and elaborated on with the goal of providing supportive evidence, complete characteristics of levels and suggesting educational interventions (e.g. Al-ebous, 2016; Burger, Shaughnessy, 1986; Clements, Swaminathan et al., 1999; Çontay, Paksu, 2012; Crowley, 1987; Erdogan, Dur, 2014; Feza, Webb, 2005; Knight, 2006; Mason, 2002; Mayberry, 1983; Musser et al., 2001; Usiskin, 1982; Van de Walle, 2001).

In our study, the importance of visualisation during the process of development of geometric terms is evident directly from the name of the zero van Hiele level. According to the van Hiele theory, the level of visualisation is characterised by the fact that a child is able to identify a geometric shape based on its visual prototype. This level is not typical of a child's own thinking but is important within the entire process. It creates conditions for another level of analysis within which one is able to distinguish important elements and properties of geometric shapes. If the provision of experiences on both levels during the educational process is omitted then the child does not have the opportunity to develop geometric thinking in more abstract forms. Educational implications of the van Hiele theory follow the phases of the instructional cycle: ***information, guided orientation, explication, free orientation and integration*** during the teaching of geometry. Details and experiences with the phases of the instructional cycle have been described in previous studies (e.g. Al-ebous, 2016; Crowley, 1987; Dongwi, 2014; Mason, 2002; Usiskin, 1982).

Jirotková (2010) provides reasons for the importance of visual imagery and states that the core of geometry is the relationship between geometric objects. Simultaneously, the conception regarding geometric objects is created in the mind via visual and tactile imagery.

When dealing with the theme of visualisation, the theory of French psychologist Duval (1995) must be mentioned, who identified reasons "why" and "how" geometry should be learnt or taught in schools. He formulated three types of cognitive processes that must be supported within the development of geometric thinking:

A) ***Visualisation processes*** in which transparent visual illustrations or representations of geometric propositions (e.g. pictures, graphs, symbols) are present; heuristic exploration of a complex geometric situation.

B) ***Construction processes*** include the use of construction tools (e.g. ruler, bow compass or dynamic software programs) for solving a geometric situation, thus creating a geometric model based on certain conditions.

C) ***Argumentation processes*** mean specific logic discursive processes for the generalisation and development of knowledge, explanation, reasoning and proofs.

These three processes may occur separately but they are also closely linked together and synergic, that is, according to Duval (1998), cognitively indispensable for acquiring geometric knowledge. Visualising means summoning up a mental image of something—seeing it in your mind (Using visualization in maths teaching, 2018a, 2018b).

From the above stated theoretical cognitive models, it is evident that ***visualisation determines the creation of correct geometric conceptions***. Therefore, it is important to implement the correct, most effective and age appropriate choice of visual models to access geometric terms within the teaching of geometry.

Research basis: conceptions of Slovakian pupils regarding rectangles

Mathematical terminology in Slovakia is different from foreign terminology in the definitions of some concepts. In Slovakian school mathematics there are several exclusive definitions. Many pupils during their mathematics education for the entire primary level have not had any experience with the notion of a "rectangle". Some teachers actively use the notions of oblong and square and they do not use the common notion, i.e. "the rectangle" for this type of shape. Other teachers do use the notion "rectangle"; however, this concept isnot included in the Slovakian national curriculum. The oblong is defined, such as a parallelogram, which is not a square and every inner angle is a right angle. The square is defined as a regular quadrilateral. For this reason, it is difficult to adapt research tools from overseas to the Slovakian conditions in the relevant form, which makes it difficult to compare research results from Slovakia and abroad. Therefore, we must consider the specific terminological conditions of each country.

From 2015 to 2017 we investigated the level of knowledge in geometry of pupils in different age groups within the project VEGA (Scientific Grant Agency of the Ministry of Education, Science, Research and Sport of the Slovak Republic and the Slovak Academy of Sciences) and APVV (Slovak Research and Development Agency). In the present study, we focused only on the description of selected results of the research concerning geometric conceptions of pupils regarding rectangles and those that have connection with the visual concepts of pupils. The results from the present study inspired the creation of educational interventions focused on the correction of long-lasting misconceptions about rectangles. The aim of the present study was to determine what misconceptions pupils have in primary schools about geometric shapes, identify the most common misconceptions and determine whether these misconceptions are minimised during the geometric education process or whether they persist because of their fixity and stability. The research sample was split into two subsamples. One subsample consisted of approximately 345 pupils in the 4th grade from 26 primary schools and approximately 10 years of age (52.5 % boys and 47.5 % girls). This subsample was a convenience sample from north and northeast Slovakian schools. Pupils solved the test of their mathematical knowledge. Administrators were trained in the organization of this test and at each of the 26 schools the administrator arranged the correctness of the data.

The second subsample consisted of 738 Slovakian pupils from the 9th grade of primary schools or the 4th grade of 8-years secondary schools (15 years old pupils, upper secondary level). The pupils were approximately 14–15 years old and 52 % were boys. This was a representative sample. The members of the research team personally administrated the objectiveness of the sampled data at every selected school without the influence of the teachers of the tested pupils.

To determine the conceptions of pupils in the 4th grade of primary school about geometric shapes and their properties, we used our non-standardised knowledge test. The conception content of the test agrees with the actual content and performance standards of the National Educational Programme (2009) and also with the Innovated National Educational Programme for Primary Education (2015) in Mathematics and work with information. These types of research tools have been applied in previous studies (for example Burger, Shaughnessy, 1986; Clements, Sarama, 2014; Hannibal, 1999; Levenson et al., 2011 and others). Some of the tasks of our test inspiration were obtained from research by the Erikson Institute (2013). Tasks on our test respected Slovakian educational conditions.

To determine the conceptions of the 15-year old pupils we used a component of van Hiele's test created for the needs of the Cognitive Development and Achievement in Secondary School Geometry (1982) project by Zalman Usiskin[*] (see Usiskin (1982)). We added five of our own tasks to obtain more accurate results because of the differences in national terminology.

The following section describes the most important results from both studied groups concerning the conceptions of pupils about rectangles in the context of visualisation, focussing on

[*] "Copyright ©1980 by the University of Chicago. Reprinted with permission of the University of Chicago (Prof. Z. Usiskin)."

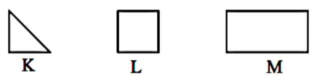
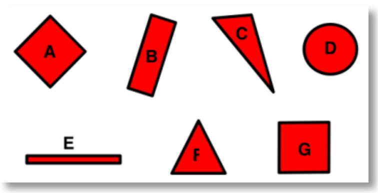
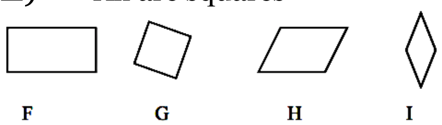
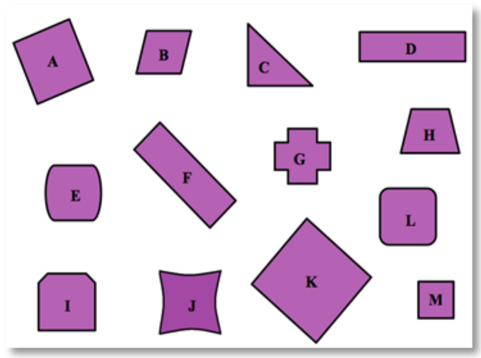
comparable and age accurate tasks used in both groups. The most frequent problems in the identification of rectangles in both groups of pupils are specified and the types of problems and misconceptions common to both groups are discussed. When determining the common problems among these groups, it was expected that the early misconceptions of pupils would be stable during their learning at both the primary and lower secondary levels. Teacher should determine educational interventions and teaching activities that eliminate the creation of these misconceptions during the early stages of the pupils' cognitive processes.

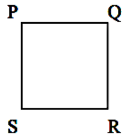
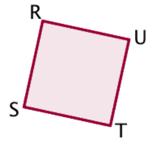
We aimed to identify the concepts of plane figures that exist for pupils in the 4th and 9th grades and whether the educational interventions of teachers in the lower secondary level eliminate the misconceptions about these plane figures. Some models of rectangles in rotated or other non-standard positions are difficult for pupils to comprehend; thus, teachers should make suitable educational interventions in these cases.

The tasks aimed at squares for the van Hiele's level of visualisation (tasks L1.1, L1.4, S1.1 and S1.2) and the analyses that contained comparable items (tasks L2.1 and S2.8) are listed in Table 1. The tasks that are denoted with the letter L are from the original test prepared by Zalman Usiskin and the tasks denoted with the letter S are from our test. The formulation of the tasks L1.1 and S 1.1 was different for the different groups of pupils. We focused on whether the pupils in both groups had the ability to identify squares. Those pupils in the 9th grade had the possibility of choosing the square because they already knew this shape; thus, we wanted to examine the ability of the pupils in the 4th grade to identify squares.

However, some tasks for these two groups of pupils were not comparable, thus we determined these via parallels in the cognitive process for pupils from both groups. For example, if the task L1.1 is oriented to the identification of squares, then we evaluate in the task S1.1 for purposes of our study only the shapes that are squares. Therefore, in task L1.1 the possibility B responds to the possibility G in task S1.1.

Table 1. Tasks concerning squares at the level of visualisation and analysis for pupils in the 4th and 9th grades

Pupils in the 9th grade	**Pupils in the 4th grade**
L1.1 Which of these are squares? A) K only B) L only C) M only D) L and M only E) All are squares  	S1.1 Write a name for each shape. 
L1.4 Which of these are squares? A) None of these are squares B) G only C) F and G only D) G and I only E) All are squares  	S1.2 Which of the shapes in the picture are squares? 

L2.1 PQRS is a square. Which relationship is true in all squares? A) PR and RS have the same length. B) QS and PR are perpendicular. C) PS and QR are perpendicular. D) PS and QS have the same length. E) Angle Q is larger than angle R. 	S2.8 STUR is a square. Circle true statements: A) Line segment RT is a side of square. B) Side SU is a diagonal of square. C) Sides RU and RT are adjacent. D) Sides SR and TU are opposite. E) Sides ST and TU have different length. F) Opposite sides in a square have same length. G) Line segments SU and SR have same length. 

The percentage share of answers for each possible answer in tasks L1.1 and L1.4 for pupils in the 9th grade are shown in Table 2. The correct answer for both tasks was B. Code 'NA' represents the situation when a pupil did not answer the task or chose multiple answers. If we compare the correct answer (G) chosen by the 4th graders for task S1.1 and the correct answer (B) chosen by the 9th graders for task L1.1, then approximately 92 % was obtained in both groups, with the percentage obtained by the 9th graders higher than that of the 4th graders.

We also compared the ability to identify a square in the rotated position—the square in task L1.4 (shape G identified by 75.5 % of 9th graders) and the square in task S1.1 (shape A identified by 54.8 % of 4th graders)—by the 4th and 9th graders.

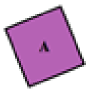
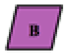
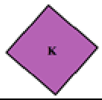
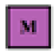
Table 2. Percentage share of answers of 9th graders for all possible answers in tasks L1.1 and L1.4 – identification of a square at the visualisation level

Task	A (%)	B (%)	C (%)	D (%)	E (%)	NA (%)
L1.1	1.22	92.28	1.08	5.01	0.00	0.41
L1.4	5.96	75.47	4.88	10.98	2.17	0.54

Both these tasks verified the level of knowledge of 9th graders in the identification of squares. Task L1.1 was relatively simple for the 9th graders, with 92.3% of pupils answering correctly and none of the pupils choosing answer E. Distractors A and C were also not very popular. The correct answer in task L1.4 was B; however, only 75.5 % of 9th graders chose this answer. A popular distractor for pupils was answer D (11 %); therefore, the pupils identified the rhombus 'I' as a square. Approximately 6 % of pupils chose distractor A; therefore, they were unable to identify a square in the rotated position.

For comparison, we chose the results of analogous tasks and comparable items from the test of pupils in the 4th grade, which are shown in Table 3. The lowest success rate of 4th graders was in the identification of models of squares in which the diagonals were in a horizontal-vertical position. The success rate for task S1.2-B was 51 %; therefore, 49 % of the 4th graders identified a rhombus as a square. The term 'perpendicularity' is not present in the national curriculum or in mathematics textbooks for primary education and pupils do not encounter this exact property (only as an intuition). Therefore, they probably thought that the rhombus in S1.2-B was a shape that was a quadrilateral and had all sides equal, with these characteristics for a 4th grader being enough for the identification of the shape as a square.

Table 3. Success rate of correct answers of pupils in the 4th grade– identification of a square at the visualisation level

Shape	S1.1-A 	S1.1-G 	S1.2-A 	S1.2-B 	S1.2-K 	S1.2-M 
Answer (%)	54.8	91.9	91.0	51.0	80.0	95.4

Active knowledge of terminology was expected from the 4th graders in task S1.1. Pupils should in this task be able to name the shapes of the figure (see task S1.1 in Table 1). If we formulate the task in this way (i.e. active terminology), then this task is much more difficult than the task where the pupils work only with passive terminology. Therefore, the results from this task were expected to be worse than the results from task S1.2.

If we compare the results between tasks S1.1-A and S1.2-K, than this is true, which is the same if we compare the results between tasks S1.1-G and S1.2-M. Pupils found it more difficult to write the name of the shape than to identify the shape according to its name.

Comparing the results between tasks S1.2-A and S1.2-K, the measure of the rotation of certain shapes influenced the pupils' ability to identify the name of the shape. A smaller angle of rotation ensured greater success for pupils when identifying these shapes.

Comparing the results from the analogous parts of tasks for pupils in the 4th and 9th grades at the van Hiele's level of visualisation (tasks L1.1, L1.4, S1.1 and S1.2) we observed an expected increase in correct answers for the 9th graders. However, in both groups there was a lower success rate for the identification of squares that did not have their sides in the horizontal-vertical position. Thus, the degree of rotation of the square affected the ability of the pupils to identify the squares. The most difficult shape to identify for both groups were those squares that had their diagonals in the horizontal-vertical position.

The percentage share of answers of 9th graders for all possible answers to task L2.1 are listed in Table 4. The correct answer for this task was B.

Table 4. Percentage share of answers of 9th graders for task L2.1

Task	A (%)	B (%)	C (%)	D (%)	E (%)	NA (%)
L2.1	12.47	46.21	24.12	14.63	1.22	1.36

Table 4 shows that the correct answer regarding the properties of a square was chosen by only 46 % of 9th graders. This is a relatively poor result given that the task only tested simple properties and relationships in squares. A relatively popular distractor was answer C, with approximately 24 % of 9th graders denoting that the opposite sides of a square are perpendicular. We were unable to determine whether the mistake was real or not, i.e. whether the pupils confused the terms perpendicular and parallel or whether it was really a misconception.

Two distractors, answers A and D, focused on verification of the ability of pupils to compare the length of a side and a diagonal in a square. Pupils in the 9th grade considered these lengths to be the same in approximately 12 % (distractor A) and 15 % (distractor D) of cases. Therefore, more than a quarter of tested 9th graders chose either distractor A or D as the correct answer, and thus they believed that the lengths of a side and a diagonal in the square are the same.

The formulation of the task for the 4th graders was different from the formulation of the task for the 9th graders. For the 4th graders, we verified whether they knew the basic terms concerning squares (e.g. side, diagonal, adjacent and opposite sides) and we also included the properties about the length of the side and diagonal of a square. The adjustment of this task was required because Slovakian 4th graders do not know the property 'perpendicular' because it is not included in the national curriculum.

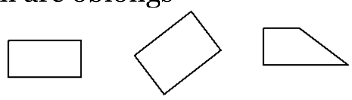
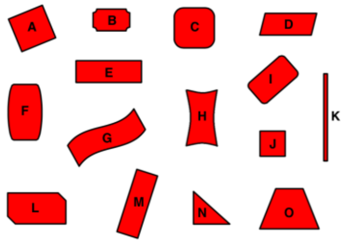
The percentage of answers of 4th graders for the statements A to G in task S2.8 (the last row in Table 1) are shown in Table 5. Approximately 80 %–90 % of 4th graders knew the basic elements of a square (e.g. side, diagonal and adjacent sides) and they knew the property about the equal length of the sides of a square. A total of 75 % of the 4th graders also knew the term ‘opposite sides’ (distractor D). Approximately 55 % of the 4th graders thought that the length of the side and the diagonal in a square was the same.

Table 5. Percentage of answers of 4th graders to statements in task S2.8

Statement	A	B	C	D	E	F	G
Answers (%)	82.6	83.7	82.6	75.6	82.9	87.8	54.5

Comparing the results of 4th and 9th graders showed that the most difficult item for both groups was to decide about the length of a side and diagonal in a square. The success rate for 9th graders for this item was higher than the success rate for 4th graders, which was expected, although misconceptions were identified in more than a quarter of 9th graders.

Table 6. Task about oblongs at the level of visualisation for pupils in the 4th and 9th grades

Pupils in the 9th grade	**Pupils in the 4th**
L1.3 Which of these are oblongs*? A) S only B) T only C) S and T only D) S and U only E) All are oblongs  	S1.4 Circle which shapes **are not** oblongs. 

In Table 6, the tasks at the van Hiele level of visualisation focused on oblongs (tasks L1.3 and S1.4). (Remark: in the Slovakian version of the original task L1.3 of the van Hiele test the word ‘rectangle’ was replaced by the word ‘oblong’ that means rectangle, i.e. is not a square. The reason for this replacement is the different national terminology.)

The percentage share of answers for the 9th graders for task L1.3 are shown in Table 7. The correct answer was answer C. The identification of an oblong at a visualisation level was not difficult for the 9th graders, although 5.56 % thought that the oblong was the shape that had its sides in the horizontal-vertical position (distractor A).

Table 7. Percentage share of answers of 9th graders for task L1.3

Task	A (%)	B (%)	C (%)	D (%)	E (%)	NA (%)
L1.3	5.56	0.54	92.28	0.68	0.81	0.14

The oblongs in task S1.4 were the shapes E, K and M, with the success rate of pupils in the 4th grade choosing these shapes shown in Table 8.

Table 8. Success rate of 4th graders choosing shapes E, K and M for task S1.4

[2] The term rectangles in the test by prof. Usiskin has been replaced by the term oblongs because the national terminology and national curriculum in Slovakia is different than English terminology and we remarked this fact in the beginning of the part 3.

Shape	E 	K 	M 
%	94.0	87.0	92.0

Comparing the results between the 4th and 9th graders in the task that focused on the identification of an oblong based on a picture showed that the conceptions of both groups were comparable. We did not find any significant progress in 9th graders compared to 4th graders.

Because 9th graders understood the term ‘rectangle’, we gave them one more task where we tested which shapes were understood by them as being a rectangle.

Task: Which shape in the picture is a rectangle?

A) Only *L*.
B) Only *K* and *N*.
C) Only *L* and *M*.
D) Only *K*, *L* and *M*.
E) All of them are rectangles.

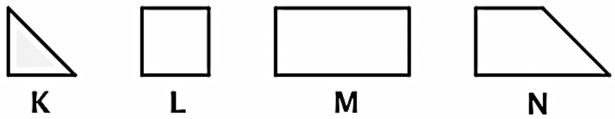


Table 9 shows the percentage share of answers of 9th graders to all possible answers of this task.

Table 9. Percentage share of answers of 9th graders for all possible answers in task about rectangles

Answer	A (%)	B (%)	C (%)	D (%)	E (%)	NA (%)
Term rectangle	3.79	14.91	40.51	11.65	26.56	2.57

The correct answer, C, was chosen by only 40.51 % of pupils. A high percentage of pupils chose distractor E as their answer; therefore, 26.56 % of 9th graders considered all shapes in the picture as being rectangles. Results showed that pupils in the 9th grade did not have an exact conception about the term ‘rectangle’. They often considered planar shapes that had at least one right angle as being rectangles. The cause of this may be the fact that 9th graders have problems with understanding the quantifier in the definition of rectangle (i.e. rectangle is a planar shape that has all inner angles as right angles) or they have created a misconception of what is and what is not a rectangle at the level of visualisation.

Findings and Discussion

Following is a summary of the problems obtained for pupils in the 4th and 9th grades in understanding the terms ‘rectangle’ and ‘square’:

- **A problem with the identification of a square in the context of its position.** The position of a square had an effect on its identification, especially for 4th graders. The degree of rotation was also an important attribute. A square, whose diagonals are in the horizontal-vertical position, was the most difficult to identify for both groups. Thus, we propose educational interventions in the set of activities for pupils where they can manipulate squares and work with rotated squares.
- **A problem with the distinction between squares and rhombuses.** A model of a rhombus was denoted as a square by 46 % of 4th graders and 11 % of 9th graders. Educational interventions to assist with this problem should include specific haptic and virtual activities. Pupils should obtain experiences with squares and rhombuses, and thus determine the differences between these shapes, as well as their common properties.
- **A problem with conceptions about the length of a side and diagonal of a square.** Pupils considered that the side and diagonal of a square were equal. These conceptions were shown in 55 % of 4th graders and 27 % of 9th graders. It is important to implement into mathematics lessons more activities oriented to recognise the different properties of squares and their important elements.

• **A problem with conceptions about the term rectangle.** Only 41 % of 9th graders were able to identify a rectangle at the level of visualisation (the term rectangle could not be examined in 4th graders because it is not a part of the national curriculum). This result is connected to the use of the term "rectangle" in Slovakian school mathematics. Thus, activities should be devoted to inquiry activities for pupils, which allow them to find inclusive relationships between squares and rectangles and also the relationships between oblongs and rectangles.

Our findings correspond with the results of other research studies (for example Burger, Shaughnessy, 1986; Clements, Sarama, 2014; Clements et al., 1999; Levenson et al., 2011 and many others).

However, the studied pupils, i.e. 4th graders and 9th graders, have different educational surroundings, and we observed analogous problems in geometrical thinking by both groups. We expect that the incorrect concepts created in the younger school age pupils influence geometrical thinking of adults (also in future teachers of mathematics at the different types of schools). Žilková (2013) identified analogous problems by students in her study—future teachers at pre-primary and primary level. She argued that their misconceptions are very stable and very difficult to eliminate. Some roots of these problems are the creation of false concepts during early childhood, and an insufficient number of suitable educational interventions from teachers at school.

A study by Erdogan and Dur (2014) showed that "the preservice mathematics teachers' knowledge of quadrilaterals learnt at primary-secondary school level and prototypical images were dominant in their personal figural concepts". Their findings underline the fact that prototypical images affected their personal figural concepts. The same findings have been shown in studies by Marchis (2012) and Çontay and Paksu (2012).

One possible reason for the creation of a false conception by pupils is insufficient educational intervention from teachers oriented to the manipulation and working with different models of shapes in different figural, positional and metrical variations. The goal of these interventions is to support the visual perceptions of pupils, which can enable better identification of shapes as planar figures that are represented not only via their prototypes. The results of the study by Clements et al. (1999) introduced the term "pre-recognition level" in the cognitive development of pupils. This study detected the fact that pupils describe shapes based on visual forms and it was possible to see individual differences in the argumentation of different pupils.

Our research did not aim to formulate any final meanings regarding pupils' thinking about geometrical shapes, which is a limitation of our research tool. We attempted to recognise some problems with the identification of shapes that were common in 4th and 9th graders. These findings are important for the educational environment because the identification of problems in the learning process provides the potential for solving these problems. The following section proposes several traditional and non-traditional educational interventions that have the potential to improve conceptions about geometric terms and relationships in rectangles.

Educational interventions: reflection on research findings via perception activities and dynamic visualisation models

The results of the present study showed problems associated with the misconceptions of pupils regarding rectangles and squares. Early education intervention may help to change misconceptions or to improve established conceptions. Therefore, mathematics teachers must include activities into their educational processes that help eliminate existing or potential problems.

In the previous section, we analysed the content of pupils' answers in two groups containing 4th and 9th graders. We identified the most common misconceptions in these two groups of pupils. In the following section, we will focus on proposals of particular activities for mathematics teachers that can help in the elimination of the above formulated misconceptions. An important role in the presentation of these educational visualisation activities is the use of appropriate software programs (e.g. GeoGebra).

In both groups of pupils, a problem with the identification of squares in non-standard positions (not with sides in a horizontal and vertical position) was seen; thus, it is necessary to create an educational environment in which pupils may encounter models of squares in different positions.

For example, it is possible to use a real or virtual geoboard to model squares of different sizes and in different positions. The aim of these activities is for pupils to realise that the change of the square's position does not mean a qualitative change in shape to another shape (i.e. a square does not stop being a square). This is shown in the following tasks, with solutions illustrated in Figure 1a and 1b.

Task 1. Model two squares on the geoboard such that their common parts are a triangle.
Task 2. Model two squares on the geoboard such that their common parts are a square.

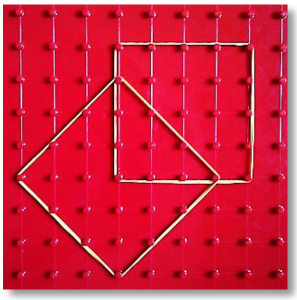


Fig. 1a. Illustration of solution to Task 1

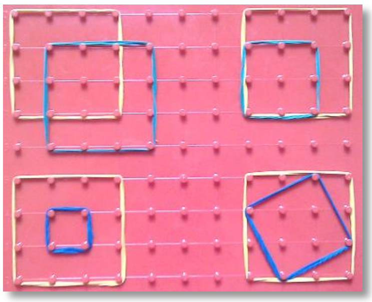


Fig. 1b. Illustration of solution to Task 2

The aim of teaching mathematics effectively is to reflect the different needs, abilities and interests of the pupils. Therefore, we recommend that a diversity of environments be used in which the activities occur. Supplementing activities from different environments ensure that the conceptions of pupils are specified. To model a square in the geoboard may be a simple activity for a particular pupil but the same task undertaken in another environment (e.g. square paper) may cause him/her problems. For another student, this might be the opposite. These observational results were collected directly during research on pupils in primary education. Therefore, an alternative task was undertaken that aimed to investigate the properties of a square after changing its position, for example, a task performed in a dynamic geometry environment or on a (virtual or printed) square grid (Figure 2).

Task 3. Draw in the square grid (using the GeoGebra software program) different squares that have vertices in grid points of a square grid.

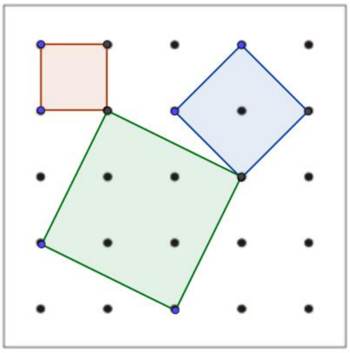


Fig. 2a. Illustration of solution to Task 3 on a virtual geoboard (Source: https://www.geogebra.org/m/wpxuvjyq)

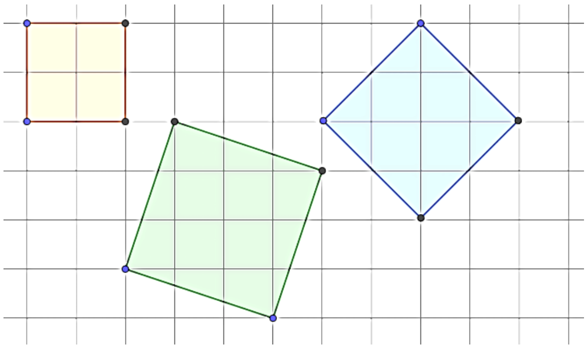


Fig. 2b. Illustration of solution to Task 3 in the GeoGebra software program environment (Source: https://www.geogebra.org/m/k5gzqebf)

To determine other properties that are involved in the process of distinguishing between squares and oblongs, it is possible to use traditional methods characteristic of mainly lower age groups of children, such as paper folding. A pupil in a lower grade is able to fold and cut a sheet of paper to create a square. In principle, this is a learnt algorithm without reasoning the sequence of instructions. In higher grades, it is necessary to discuss the reasoning behind the algorithm, thus reasoning each step involved in the folding and cutting (Figure 3).

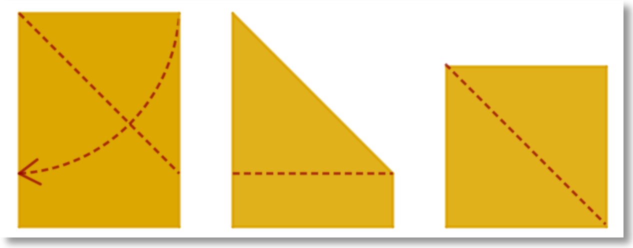


Fig. 3. Illustration of algorithm of paper folding – model of a square

Paper folding enables the verification of some of the properties of a square, such as congruity of sides, symmetry in a square and the perpendicularity of the diagonals. Similarly, the properties of oblongs can be illustrated.

It is possible to investigate the difference between rectangles and other parallelograms using a real model composed of wooden sticks connected with rivets (Figure 4). This model enables changing of the size of the inner angles of the parallelograms. This model can not only distinguish between models and non-models of oblongs but it also creates situations for realising the inclusive relationship between rectangles and parallelograms.

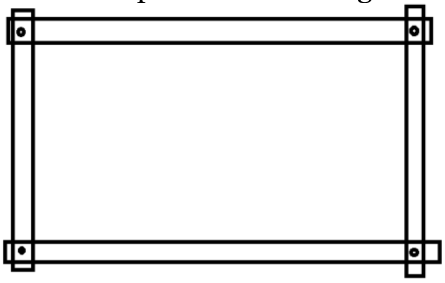


Fig. 4. Illustration of a real model used to distinguish between rectangles and parallelograms

We were able to formulate analogous problems in the dynamic geometry environment. Manipulation of interactive and dynamic applets (Figures 5a–5c), in which the position and metric properties of shape could be changed, enabled us to examine not only the properties of individual shapes but also the inclusive relationships between sets of shapes.

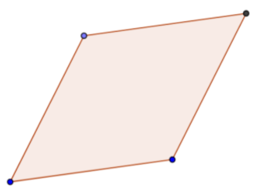


Fig. 5a. Interactive models of rhombuses
Source: https://www.geogebra.org/m/dEgASnxY

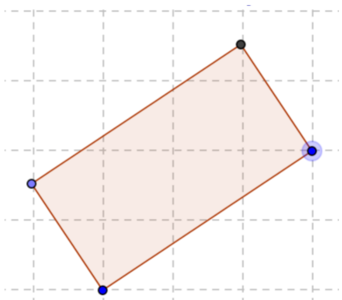


Fig. 5b. Interactive models of rectangles
Source: https://www.geogebra.org/m/ReGb6RvB

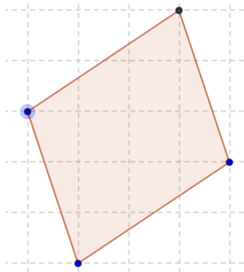


Fig. 5c. Interactive models of parallelograms
Source: https://www.geogebra.org/m/kkk8rgmq

Experimenting with the position of points or with the length of line segments that form the boundary of a quadrilateral allows the pupil the opportunity to examine the properties of the entire class of quadrilaterals, simulate different situations and answer questions or tasks such as: *"Is every oblong a parallelogram? Is every square a parallelogram? Is every rhombus a parallelogram?"* In the mentioned examples, a model from a class of rhombus is created such that changing position and metric properties might lead to the creation of a model of a square as a special type of rhombus.

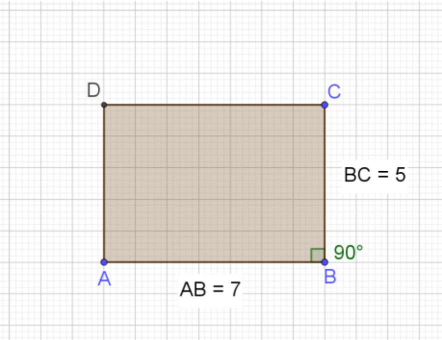


Fig. 6a. Visualisation of properties of rectangles
Source: https://www.geogebra.org/m/gqmqryfy

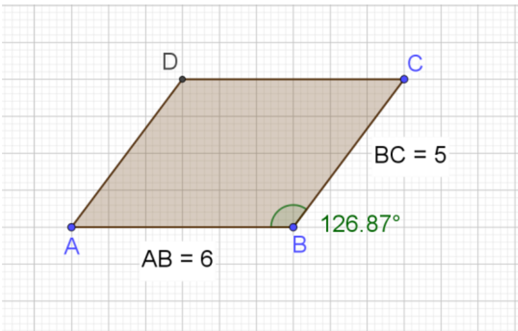


Fig. 6b. Visualisation of properties of parallelograms
Source: https://www.geogebra.org/m/gqmqryfy

Similarly, a model from a class of rectangles can be constructed so that manipulating the vertices of the parallelogram leads to the visualisation of any type of parallelogram (e.g. square, rhombus, oblong, rhomboid). The interaction in the applet concerning rectangles allows the opportunity to model and manipulate oblongs and squares in different positions. In interactive models for older pupils, we recommend also visualising the metric properties (e.g. length of sides, size of angles; Figures 6a and 6b).

An appropriate applet for distinguishing between models and non-models of rectangles is one in which the sizes of all inner angles of polygons are visualised (Figure 7). It is possible to modify this applet for models and non-models of rectangles if we position rectangles and other shapes, where we explain the relationships between their basic elements (e.g. relationships between sides and their length, size of inner angles etc.), into the square grid. These activities may be similarly modelled on a geoboard.

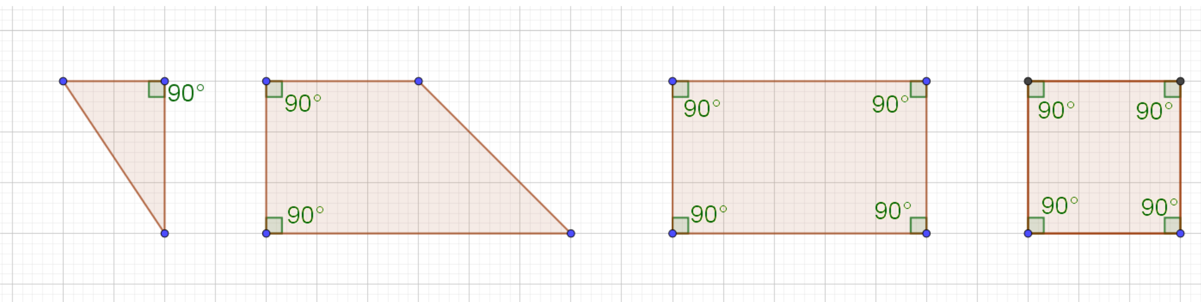


Fig. 7. Visualisation of models and non-models of rectangles
Source: https://www.geogebra.org/m/m7hmkmtc

The results from testing the 4th and 9th graders showed that pupils from the 5th to the 9th grade are insufficiently familiarised with the relationships between basic elements of a square, such as the sides and diagonals. The majority of tested pupils in the 9th grade considered the length of the side and the diagonal of a square as being the same. To eliminate these misconceptions, it is possible to use an applet (Figure 8) that enables the comparison of the lengths of line segments *SQ*

and *SP* (diagonal and side of a square) using motion of the point Q_1. Analogous activity may be undertaken with the use of point P_1 and by comparing the lengths of line segments *RP* and *RS*.
By moving points *S* and *R* it is possible to continuously change the length of the side *RS* and also its position in the plane. Thus, it is possible to show pupils that the length and position of the diagonals of a square *PQRS* are perpendicular, all the inner angles are right angles and the sides are of equal length.

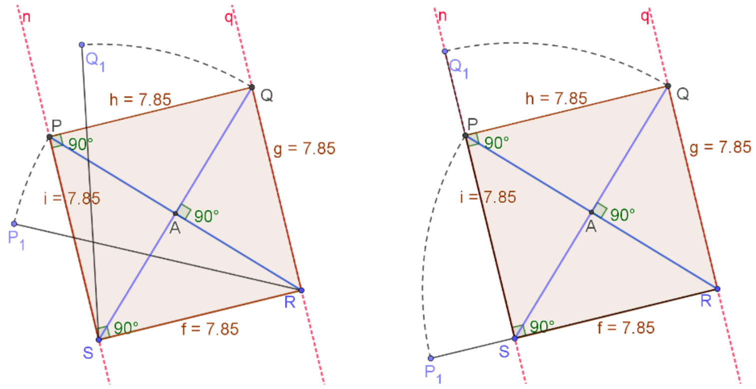


Fig. 8. Applet in GeoGebra software program
Source: https://www.geogebra.org/m/uzfk5xrq

The majority of the tested pupils in the 9th grade had problems with the terms perpendicularity and parallelism of line segments, with only 24 % of these pupils denoting that opposite sides of a square are perpendicular. Thus, we can use an applet in which the work with the square is realised on square ground (Figure 9). Points *R* and *S* can be moved to grid points on the geoboard to create different squares *PQRS*. In all cases, the line segments *PS* and *QR* are parallel. It is appropriate to combine this activity with a concrete manipulative activity on a real geoboard.

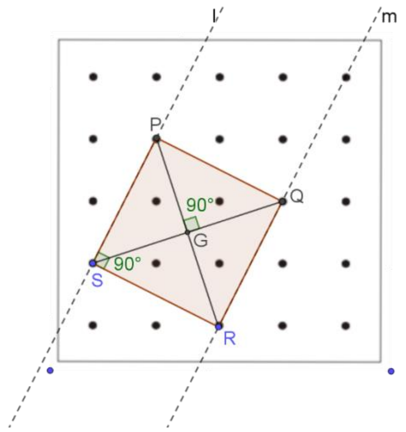


Fig. 9. Square PQRS on geoboard
Source: https://www.geogebra.org/m/mwmv3f4r

3. Conclusion

The results of testing pupils in the 4th and 9th grades (primary level, lower secondary level) showed some misconceptions exist regarding geometric terms and properties despite education. One of the on-going misconceptions is the identification of squares that do not have sides in a vertical and horizontal position. For both groups of pupils, such squares were difficult to identify. It was also shown that a low level of knowledge existed regarding the relationships between basic elements of rectangles (e.g. sides, diagonals) throughout school years, particularly with the comparison of the lengths of sides, diagonals, angles between them, and their perpendicularity and parallelism. Pupils in the 4th and 9th grades also showed decreased abilities to identify rectangles that were not squares. A similar problem was found when distinguishing between squares and rhombuses. Moreover, the 9th graders showed a low ability to distinguish between quadrilaterals that were rectangles and those that were not.

Our research findings led to the projection of activities focused on educational intervention in teaching about rectangles. The aim of the prepared activities and applets presented in the present study was to reduce the misconceptions by pupils about rectangles using dynamic visualisation. These activities focused on visualisation using appropriate educational software programs that should be supported with the use of other activities that utilise real models and appropriate manipulative activities. The more different stimuli and environments a teacher can offer, the earlier the enhancement of their students' geometric conceptions can occur. In ideal cases, pupils would participate in the creation of real and virtual models (for example through project education), which support constructivist approaches in education with an emphasis on enquiry education. As mentioned previously, Duval (1998) discusses the synergy of three processes that are essential for the development of geometric thinking. The suggested manipulative and virtual activities or applets create an educational environment in which visual, constructional and argumentative processes supplement and support each other.

If we want to increase the level of geometric thinking of pupils, it is necessary to personalise education based on the abilities, needs and interests of pupils. Such personalisation may be supported by multiple visual methods shown in the present study. To ensure that this visualisation in education is effective, the choice of the method of visualisation of geometric terms, relationships and construction procedures is subject to the personal educational styles of the pupils and their preferences.

4. Acknowledgements

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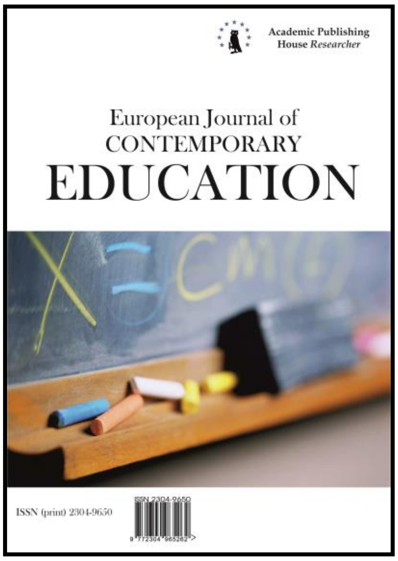

Visualisation of Selected Mathematics Concepts with Computers – the Case of Torricelli's Method and Statistics

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Abstract

Visual imagery has been an effective tool to communicate ideas connected with basic mathematics concepts since the dawn of mankind. The development of educational visualisation technology allows these ideas to be demonstrated with the help of some educational software. In this paper, we specifically consider the use of GeoGebra, a free, open-source educational application developed by an international consortium of mathematics and statistics educators, but other educational software could also be used for the same visualisation tasks.

In this study, we present Torricelli's method for measuring the area under arc of cycloid as an example of using GeoGebra to visualise he area of planar figures. This kind of introduction is suitable for secondary schools and for training pre-service teachers.

We will also show how GeoGebra can be used to develop students' understanding of representing data (i.e. the topic from statistics education). While students explore the visualisation of data, GeoGebra allows them to create and explore representations while building the understanding that is required for analysing data and drawing figural conclusions from graphical representations.

Keywords: measuring, Cavalieri's method of indivisibles, Evangelista Torricelli, the area under arc of cycloid, visualisation in statistics education.

1. Introduction

The theory of mathematics education developed by Hejný (see Hejný et al., 2006) identifies stages of gaining knowledge. Hejný described each of these stages of cognitive processes in mathematics. He defined the following stages: motivation, isolated models, generic model, abstract knowledge and crystallisation. An isolated model is a model used for explaining a concept.

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For example, one car or one pen is an isolated model for the number one. A generic model can be one finger (mostly used by children). Isolated and generic models play important roles in this theory. In order to explain a mathematical concept, it is useful to use some explanations used in the history of mathematics.

In the following section, we present an example of a visual and geometrical representation of the measurement of the area under the arc of cycloid. This representation was developed by Evangelista Torricelli (1608–1647) using the geometrical application of Cavalieri's method of indivisibles. We present some modern possibilities of geometrical visual representations prepared in GeoGebra (see also Koreňová, 2016). These presentations have dynamic components in some cases.

Torricelli lived in the beginning of the 17th century, when there was no established formal logic or style of mathematical argumentation, to say nothing of formal proof. For this reason, Torricelli used multiple kinds of argumentation to be certain about his final conclusions. Modern students can also develop better understandings of concepts when they are exposed to multiple explanations.

2. Discussion

Genesis of Torricelli's Appendix on Measuring the Cycloid

Torricelli's measurement of the area under the arc of cycloid is appended to the end of his treaty entitled *On measuring the parabola* (see Figure 1).

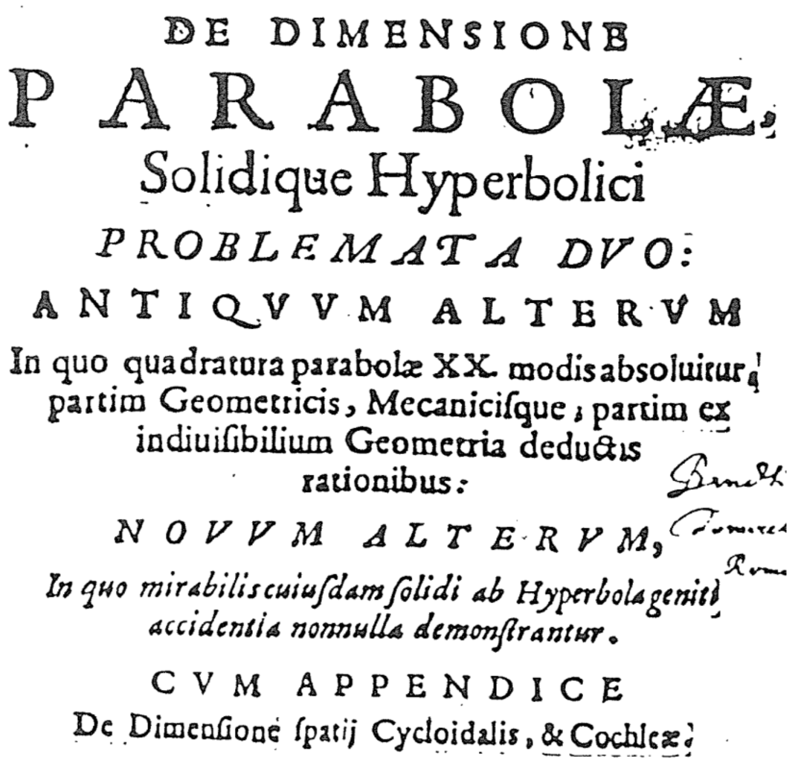
DE DIMENSIONE
PARABOLÆ,
Solidique Hyperbolici
PROBLEMATA DVO:
ANTIQVVM ALTERVM
In quo quadratura parabolæ XX. modis absoluitur, partim Geometricis, Mecanicisque; partim ex indiuisibilium Geometria deductis rationibus:
NOVVM ALTERVM,
In quo mirabilis cuiusdam solidi ab Hyperbola geniti accidentia nonnulla demonstrantur.
CVM APPENDICE
De Dimensione spatij Cycloidalis, & Cochleæ.

Fig. 1. Front page of Torricelli's treaty about measuring a parabola

The problem of the cycloid was well known at the time. In Italy, the first to consider the cycloid was Galileo Galilei (1564–1642), followed by his disciples Bonaventura Francesco Cavalieri (1598–1647), Evangelista Torricelli (1608-1647) and Vincenzo Viviani (1622–1703). In France the cycloid was the focus of the work of Marin Mersenne (1588–1648), Gilles Personne de Roberval (1602–1675), Pierre de Fermat (1607–1665), Blaise Pascal (1623–1662) and Rene Descartes (1596–1650). In England, Sir Christopher Wren (1632–1723) found that the length of the cycloid is eight times longer than the radius of the rolling circle.

Galilei had tried to estimate the area under the arc of cycloid. He assumed that this area was equal to "three times the area of the rolling circle". Not being able to prove it, he hung physical shapes on a balance to compare their weight. Due to problems with that method, he concluded that the area under the cycloid might be less than his original belief (that it was three times the area of the generating circle). Torricelli later proved that Galilei was correct by using the work of his colleague Cavalieri (see also Fulier, Tkačik, 2015).

Torricelli used expressions like "a rectangle which is equal to two circles" to prove that if we assume that two regions in a plane are included between two parallel lines in that plane, then when these two lines intersect, both figures in the line segments of equal length have equal areas (see Howard, 1991). He compares the area of a complicated planar figure with the area of a simple planar figure.

Torricelli's text on the area under an arc of cycloid shows the emergence of a new language which gave mathematics new power in the 17th century. In the original text, Torricelli used abbreviated language – for example "*AB* and *CD* are the same", meaning "the segments *AB* and *CD* have the same length"; and "The shapes *AC* and *KM* are the same", meaning "The shapes *ABCD* and *KLMN* have the same area." He used less precise argumentation because many arguments are made in the form of figures.

We present in the next parts the original Latin text in the form of a close paraphrase of the original text from the Appendix (see Appendix 1 for Torricelli's original Latin text).

We use argumentation that is more readable than in the original. Figures prepared in GeoGebra provide visualisation of the arguments, but other software could have been used (see Vančová, Šulovská, 2016).

Presentation of the Supplement (Appendix) on Measuring the Cycloid

Let us suppose that on a certain fixed line *AB*, there is a circle *AC* touching the line *AB* at the point *A*. Let us assume that point *A* is fixed on the circumference of the circle *AC*. Now let us imagine the circle is moving on the fixed line towards point *B* and at the same time revolving so that some point of the line *AB* is always touching the circle, until the fixed point returns to touch the line at the point *B*.

It is certain that point *A*, which is on the circumference of the moving circle, describes a line which at first rises from the line *AB*, culminates around *D*, and then bowing, descends towards point B. A line such as *ADB* is called a cycloid and the line *AB* was called the base of the cycloid, and the circle *AC* its generator.

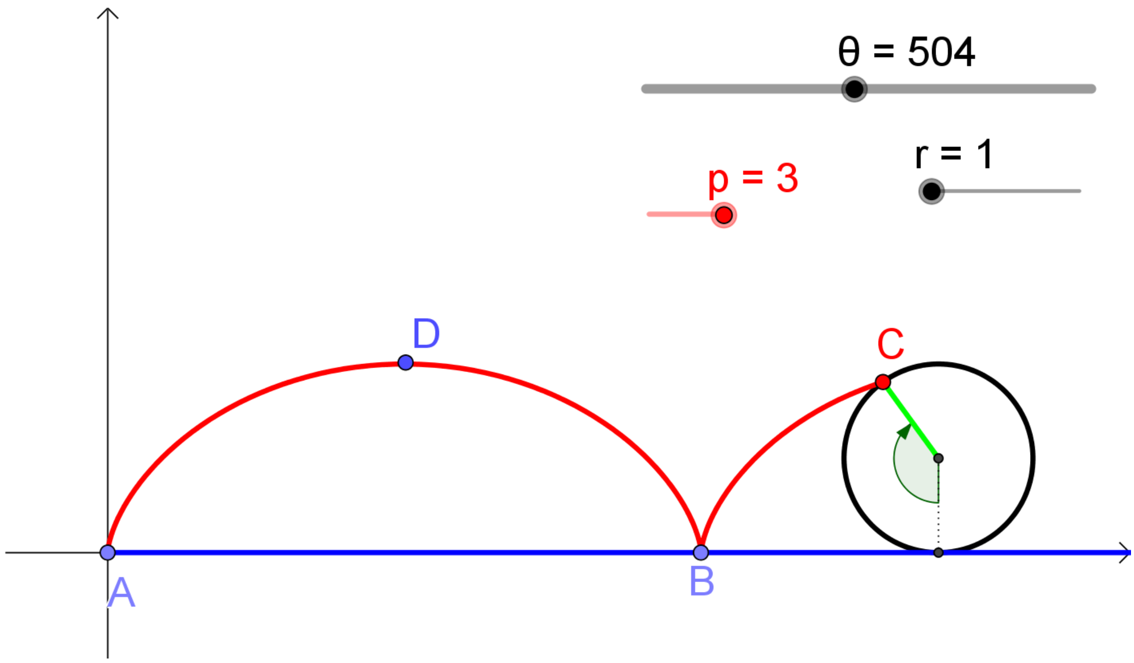

Fig. 2. Visualisation of the definition of cycloid (compare with Figure 16 in Appendix 1)

The character and property of a cycloid is such that the length of its base *AB* is equal to the circumference of the generating circle *AC*. A question arises about the ratio of the area under the arc of the cycloid *ADB* to the area of the generating circle *AC*. We shall show that it is triple. (In GeoGebra, we can move the slider θ (see Figure 2), and the circle moves with the point *C*.)

Torricelli included three proofs/arguments, each entirely different from the other. Torricelli argues as follows:

"The first and the third proceed according the new method of indivisibles. The second is by false assumption, according to the ancient customs, so that advocates of both should be satisfied. We would remind you that almost all principles according to which something is proved by the method of indivisibles could be reduced to the indirect proof, which was customary for the Ancients: this was done by us in the first and in the third of following theorems as well as in many other cases. In order not to abuse the readers' patience, most of them will be omitted, and we shall show only three."

Theorem I

The entire area of the shape between the line of a cycloid and the straight line of its base is three times the area of the generating circle or one-and-half times the area of the triangle that has the same base and height.

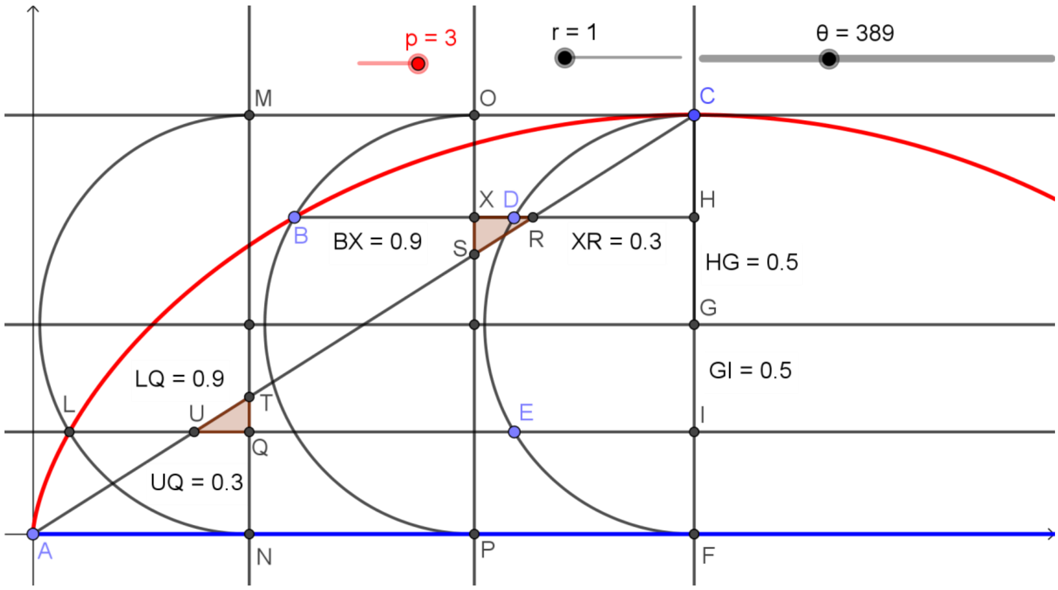

Fig. 3. Visual presentation of the picture in Figure 17 in Appendix 1

Let *ABC* be a cycloidal line traced by point *C* of the circle *CDEF* when it is rolling on a fixed base *AF* (we consider half of the circle and half of the cycloid only to avoid complicating the drawing, see Figure 3). Figure 3 presents the picture from Figure 17 in Appendix 1. It is possible to move with point B and to show that the triangles *SXR* and *UTQ* are the same.

We say that the area under half of the arc of the cycloid *ABCF* is equal to three times the area of the semicircle *CDEF*, or one-and-half times bigger than the area of the triangle *ACF*. Let us take two points *H* and *I* on the diameter *CF* at the same distance from the middle point *G*. Extending from these points are lines *HB*, *IL* and *CM*, which are parallel to the same line *FA*. *HB* passes through point *B* of the semicircle *OBP*, and *IL* passes through point *L* of the semicircles *MLN*. Both of these semicircles are equal to semicircle CDF and touch the base *FA* at points *P* and *N*. It is evident that segments *HD*, *IE*, *XB* and *QL* are equal and that using Proposition 14 of Book III (of Euclid's Elements) results in the arcs *OB*, *LN* being equal as well. The segments *GH* and *GI* are the same; hence, segments *CH* and *IF* are equal.

The whole circumference *MLN* before the cycloid (on the left) is equal to the segment *AF*. Furthermore, the arc *LN* is equal to the segment *AN* for the same reason, and because the length of the arc *LN* is the same than the length of the segment *AN*, the remaining arc *LM* will be equal to the remaining segment *NF*. For the same reason, the arc *BP* is equal to the segment *AP*, and the arc *BO* is equal to segment *PF*.

In addition, the segment *AN* is equal to the arc *LN*, to arc *BO* or to the segment *PF*. Triangles *ANT* and *COS* are the same, so the segment *AT* is equal to *SC*. Moreover, because the segment *CR* is then equal to *AU*, the remaining segments *UT*, *SR* are equal as well. Therefore the equiangular triangles *UTQ*, *RSX* have equal corresponding sides *UQ*, *RX*. It is therefore evident that the length of two segments *LU*, *BR* taken together are equal to the sum of the two segments *LQ*, *BX*, and for the same reason, they are equal to the length of the sum of the segments *EI*, *DH* – something that will always be true. When two points *H* and *I* are equally remote from the middle point *G*. Therefore, all segments of the geometric figure *ALBCA* are equal to all the segments of the semicircle *CDEF*.

However, the triangle *ACF* is twice the semicircle *CDEF* because triangle *ACF* is reciprocal to the triangle described by Archimedes in *On measuring of the circle*, when the side *AF* is equal to the semicircle and when *FC* is the diameter. Therefore, triangle *ACF* is equal to the whole circle whose diameter is *CF*.

In summary, the area under one half arc of cycloid is one-and-half times the area of the triangle *ACF* and therefore three times the area of the semicircle *CDEF*. Thus, the area under the arc of cycloid will be three times the area of the circle whose diameter is *CF* (i.e. the generating circle).

Lemma I

We suppose that on the opposite sides of an arbitrary rectangle AEFD we draw two semicircles EIF and AGD. The figure contained between their outlines and the remaining sides is equal to the initial rectangle AEFD (see Figure 4).

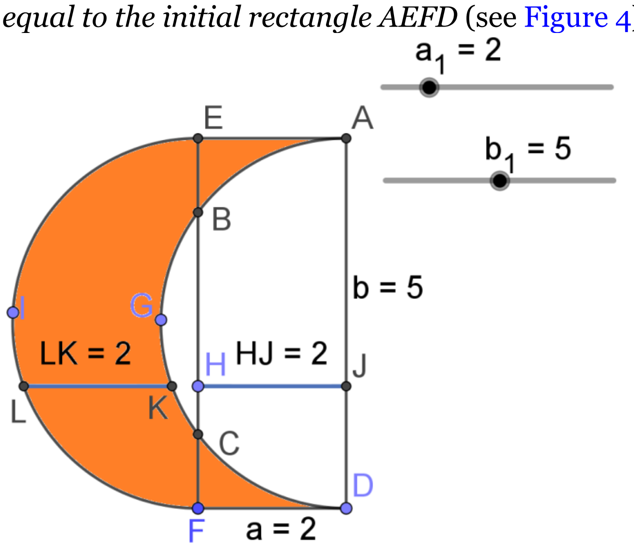

Fig. 4. Visual presentation of the picture on the Figure 18 in Appendix 1

Figure 4 presents a visualisation created by a GeoGebra applet, in which slider a_1 can change the length of the segment *AE* and slider b_1 can change the length of the segment *AD*. If we move point *H*, the segments *LK* and *HJ* remain the same. The shape *ABCDFLE*, which is marked in the Figure 4 with the colour, is called the *arc shape*.

The proof of Lemma 1 is as follows: Since the semicircles *AGD*, *EIF* are equal, after subtracting their common part *BGC* and adding the two three-sided figures *EBA* and *CFD*, the proposed thesis is clear (a geometrical application of Cavalieri's method of indivisibles).

In case there is no common part, the proof is easier. By subtraction, the arc shape, which is cut through some line parallel to segment *FD*, can be shown to be equal to the rectangle of the same height and built on the same base.

Lemma II.

Let the cycloidal line ABC be drawn from point C of a semicircle CDE, which rolls on the fixed line AE. The rectangle AFCE is completed so that a semicircle AGF rises next to AF. We say that the cycloid ABC cuts the arc shape AGFCDE in halves (see Figure 5).

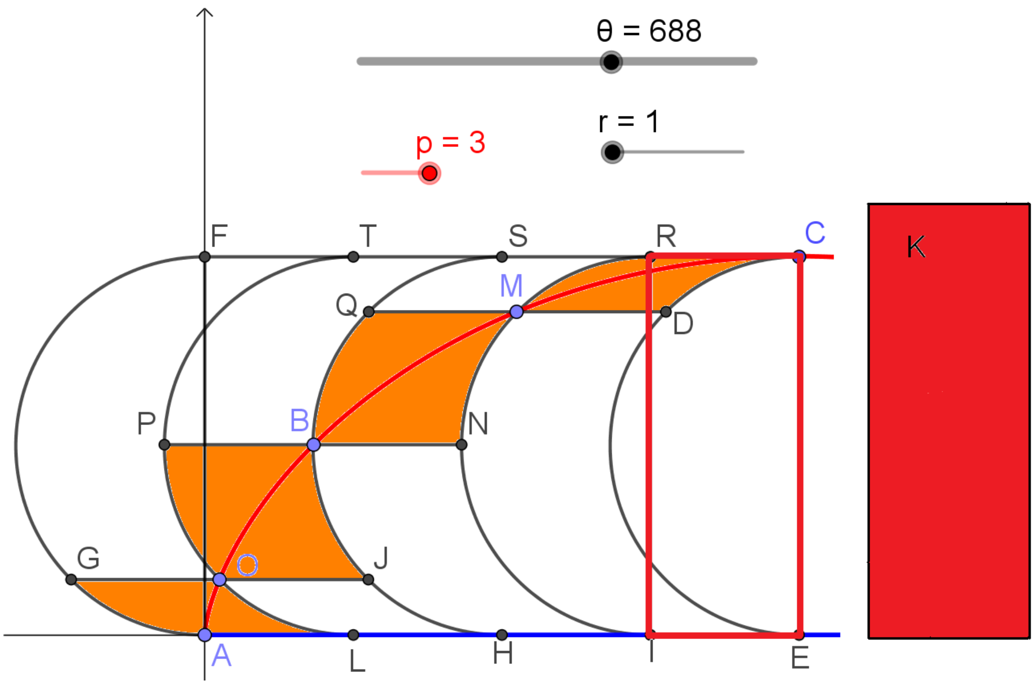

Fig. 5. Visual presentation of picture for Lemma II from Figure 19 in Appendix 1

This proof will be absurdum proof, then one of the three-sided figures *FGABC*, *ABCDE* would certainly be greater than half of the area of the arc shape *AGFCDE*. If the area of one of the arc shapes namely *ABCDE* is greater than half of the arc shape *AGFCDE*. Let the excess part, by which the three-sided figure is greater than half of the area of the arc shape, be equal to the area of a certain shape *K*. This approach is geometrical application of the "ε-δ technique". The area of a certain shape *K* is a geometrical representation of the number ε.

Let *AE* be cut into halves by a point *H*, and then *HE* by point *I*. And let it continue in cutting of *AE* (points *L*, *I*, ...)until some rectangle *IECR* is smaller than the area of the shape *K*. The whole *AE* is then divided into parts that are equal to the segment *IE*. Let semicircles be drawn through points *L*, *H*, *I* – equal to the semicircle *CDE*, touching the base *AE* at points *L*, *H*, *I* and cutting the cycloid at points *O*, *B*, *M*, through which straight lines GO, PB, QM are drawn parallel to the base *AE*.

Therefore, the areas of the arc shapes *OLHJ*, *GALO* are equal; the areas of the arc shapes *BHIN* and *PLHB* are equal; and the areas of the arc shapes *MIED*, *QHIM* are equal. Therefore, the area of the whole figure consisting of arc shapes *OLHJ*, *BHIN, MIED*, which are contained in the three-sided arc figure *ABCDE*, is equal to the area of the figure just circumscribed on the same three-sided figure, excluding the arc shape *IMRCDE* (which consists of the arc shapes *GALO*, *PLHB*, *QHIM*). And if the arc shape *IMRCDE* is added to this circumscribed figure, then its area becomes greater than the area of the one inscribed by the mentioned arc shape or by rectangle *RIEC*, which is of course less than the shape *K*. Therefore, the area of the figure contained in the three-sided arc figure *ABCDE* is greater by that amount (the area of the rectangle *RIEC*) than half of the area of the arc shape *AGFCDE*, and thus it is greater than a three-sided arc figure *FGABC*. However, it is equal to another figure composed of arc shapes in the three-sided arc figure *FGABC*. And this figure would be bigger than the figure *FGABC*, a part greater than its whole, which is impossible.

It is clear that the areas of the inscribed figures (arc shapes) are equal. Specifically, the arc *OL* is equal to the segments *LA* or *IE* or to the arc *RM* (above the cycloid). Therefore, the area of the arc shape *OLHJ* is equal to the area of the arc shape *QMRS* – and so on with each of them (pairs of the arc shapes *PBST*, *BHIN* and *GOTF*, *MIED*). If we suppose, in fact, that the area of the three-sided arc figure *FGADC* is greater than half of the area of the arc shape *AGFCDE*, the construction of figures and the proof are entirely the same. Thus, the conclusion is that the cycloidal line *ABC* divides the arc shape *AGFCDE* into two shapes with the same area.

Theorem II

The area under the arc of cycloid is three times bigger than the area of the generating circle.

Let a cycloid *ABC* be traced from point *C* of the circle *CFD*. We say that the area under half of the arc of cycloid (the shape *ABCD*) is three times bigger than the area of the semicircle *CFD*. In a rectangle *ADCE*, the side *AE* is completed by a semicircle *AGE* (see Fig. 6), and the segment *AC* is drawn.

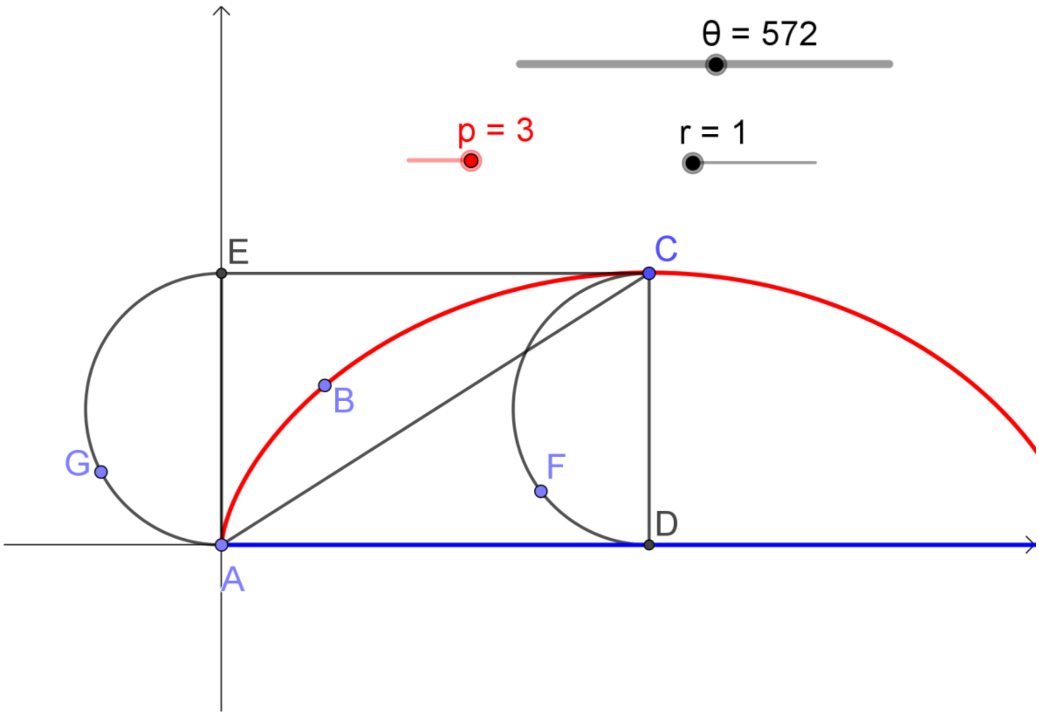

Fig. 6. Visual presentation of picture from Figure 20 in Appendix 1

The area of the triangle *ADC* is two times the area of the semicircle *CFD*, because the base *AD* is equal to the circumference *CFD* (this follows from the construction of the cycloid, and the height is equal to the diameter). Therefore, the area of the rectangle *ADCE* is four times the area of the semicircle *CFD*. Thus, the area of the arc shape *AGECFD* is four times the semicircle; the three-sided arc figure *ABCFD* (from the preceding lemma) is two times the semicircle; and the area of the shape under half of the arc of the cycloid *ABCD* is three times the area of the semicircle *CFD*. For this reason, the area of the shape under the whole arc of the cycloid is three times the area of the circle that generates the cycloid.

Theorem III.

The entire area of the shape under the arc of cycloid is three times bigger than the area of the circle that generates the cycloid.

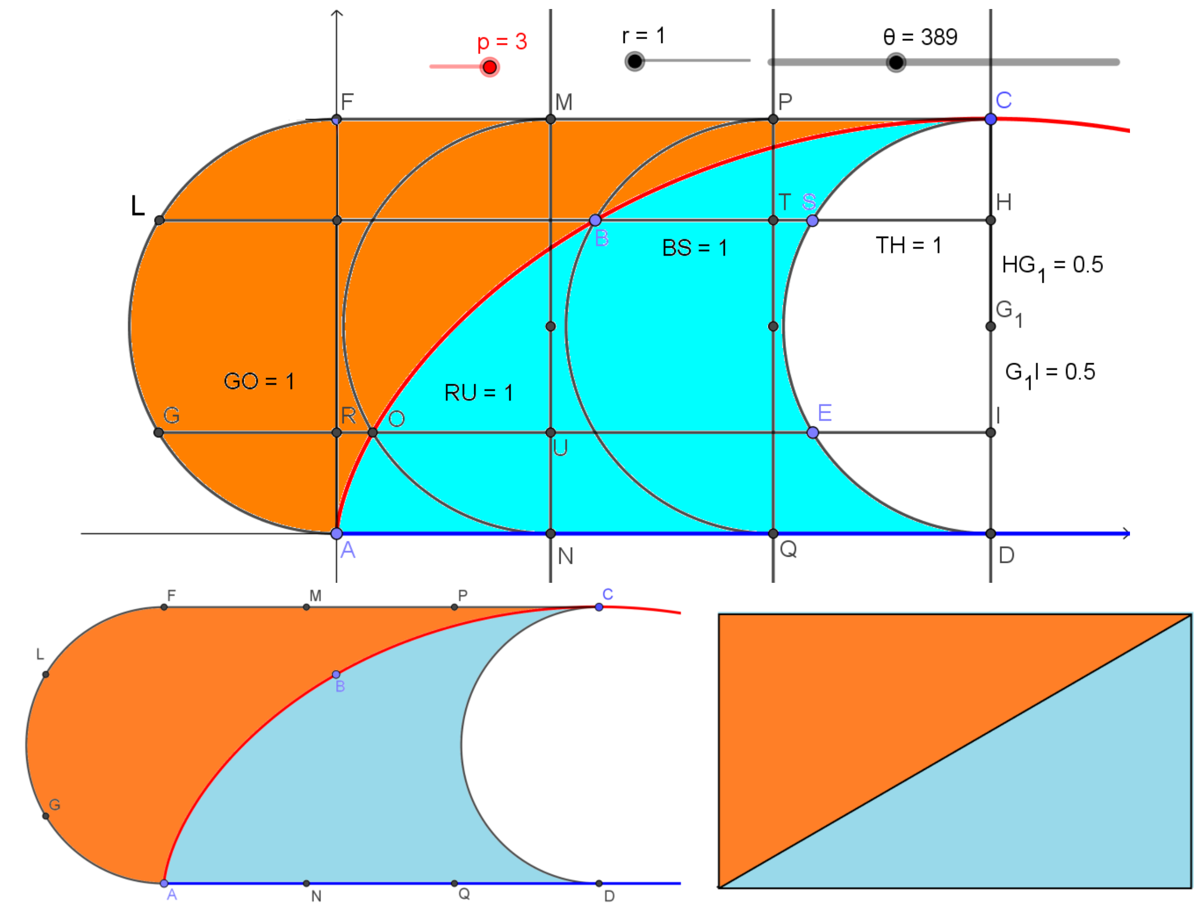

Fig. 7. Visual presentation of Figure 21 in Appendix 1 with analogy between arc shape and rectangle

Let the cycloidal line *ABC* (see Figure 7) be drawn from the point *C* of the semicircle *CED*. We say that the area of the arc figure *ABCD* is three times bigger than the area of the semicircle *CED*. Let us draw the rectangle *AFCD* and fix two points *H* and *I* on the diameter *CD* of the semicircle *CED* at the same distance from the middle G_1 of *CD*. Then, let lines *HL*, *IG* be drawn parallel to *AD*, cutting the cycloid at points *B* and *O*. Finally, let us draw through point *B* and through point *O* two semicircles *PBQ* as *MON* as done previously (with the same diameter as diameter *CD*).

Now the segment *GO* is equal to the segment *RU* (since segments *GR*, *OU* are equal and since *RO* is a common part), equal to the segment *AN* as well as to the length of arc *ON*, arc *PB*, segment *PC*, segment *TH* and segment *BS*.

Similarly, as it was shown that the segment *GO* is equal to the segment *BS*, we also show that all the segments together of the three-sided arc figure *FGABC* and each of them separately are equal to all segments of the three-sided arc figure *ABCED*. Therefore, the three-sided arc figures *FGABC*, *ABCED* are equal. Hence, as in the previous theorem (Theorem II), the area of the shape under half of the arc of the cycloid *ABCD* is three times bigger than the area of the semicircle *CED*, and the area of the shape under the arc of the cycloid is three times bigger than the area of the circle that generates the cycloid (see Figure 7).

The result is also that cycloid arc *ABC* cuts the arc shape *FGADC* into two arc shapes with the same area. Analogically, a diagonal cut of some rectangle also results in two triangles with the same area.

The following figure is a visual presentation of Cavalieri's method of indivisibles in this theorem (see Figure 8).

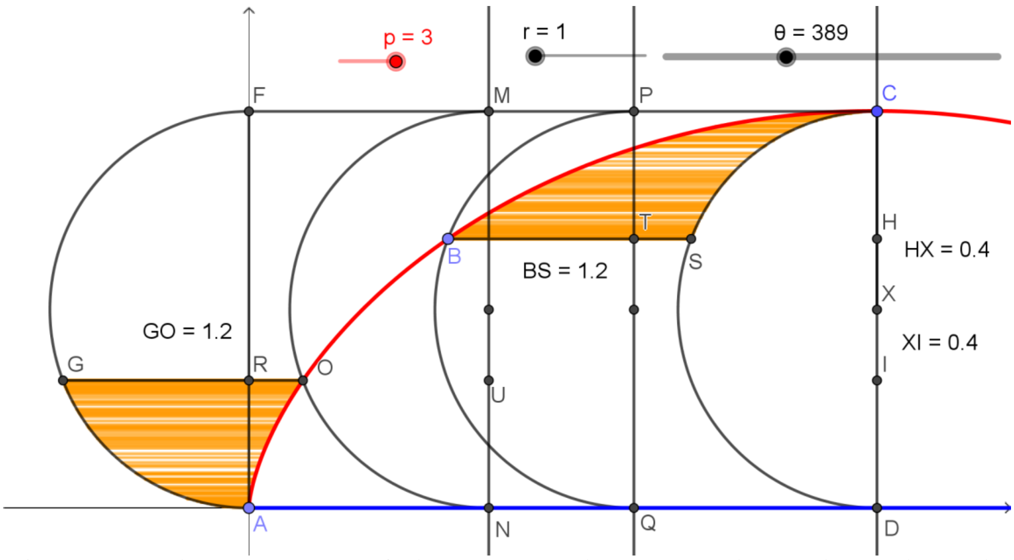

Fig. 8. Visual presentation of Theorem III (the orange planar shapes have the same area)

If we move with point *B* (see Figure 8), we obtain orange planar figures (the GeoGebra function "Trace on" used for the segments *GO*, *BS*). The segments *GO* and *BS* are always the same, and according Cavalieri's method of indivisibles, these shapes have the same area.

Remarks on the Torricelli Approach of Using Cavalieri's Method of Indivisibles

Gilles Personne de Roberval (1602–1675) also studied the cycloid and introduced the term "socia". If we have half of the arc of cycloid *AGB* (see Figure 9) in the rectangle *ADBE*, we can make a picture of this arc in the central symmetry with the centre *S*. The point *S* is a centre of the rectangle *ADBE*. We obtain an arc *AHB*. We can move with the segment *GH*, which is parallel to segment *AD*, and the points *G*, *H* are points of these central symmetry cycloid arcs. The centre *S* of the segment *GH* (see Figure 9) describes a part of the curve that is practically sinusoidal. Points *I*, *J*, *G*, *H* are on the same line, and the lengths of the segments *IJ* and *GH* are the same.

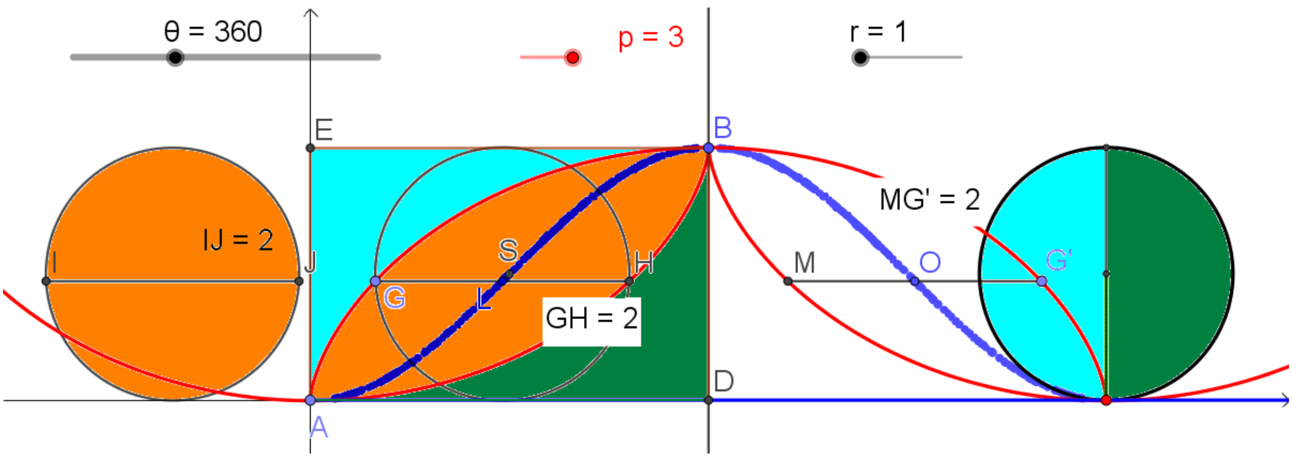

Fig. 9. Visual presentation of Roberval's "socia" (blue colour) via GeoGebra
(the plane figures with the same colour have the same area)

The area between these two cycloid curves has a "spindle" shape. It is an interesting property that points of both cycloid curves are on the same rolling circle (the orange circle in Figure 9). The segments *IJ* and *GH* are the same, and according to Cavalieri's method of indivisibles, that "spindle" shape has the same area as the rolling circle. If the area of the shape under half of the arc of a cycloid is equal to one and a half of the area of the rolling circle, then the area of the shape under the second (down) cycloid curve is equal to one half of the area of the rolling circle. This is visualised by GeoGebra in Figure 9.

Visualisation in Statistics Education

We also can use GeoGebra as a tool to help students appropriately visualise data in order to analyse and interpret that data because visualisation is critical for teaching and learning data. As Prodromou (2014) discusses, GeoGebra can be implemented into the curriculum and learning process of introductory statistics to engage college students (and secondary students) in cycles of statistical investigations, including (a) managing data, (b) developing students' understanding of specific statistical concepts, (c) conducting data analysis and inference and (d) exploring probability models.

GeoGebra is used in two distinct ways when teaching introductory statistics (Prodromou, 2014):

(1) Applets created with GeoGebra are implemented into teaching practices to demonstrate specific concepts.

(2) Students use GeoGebra as a software tool to perform data analysis and inference and to develop probability models.

GeoGebra applets can be used during teaching practices to visually represent particular fundamental concepts that are commonly difficult to conceptualise. Furthermore, most of the applets make it possible to interact with parameters and variables by altering sliders, using dynamic representations as tools for analysis, formulating personal models, calculating probabilities, communicating dynamic changes of data visualisations and storing and processing real data.

For example, when students begin to learn how the normal distribution approximates binomial probabilities, we use the following GeoGebra applet (see Figure 10) to visualise statistical distributions when the parameters and variables are altered using sliders.

More specifically, this applet allows students to manipulate *n*, which indicates the random sample of a number of people who participated in a research study, and *p*, which indicates the probability of an event occurring.

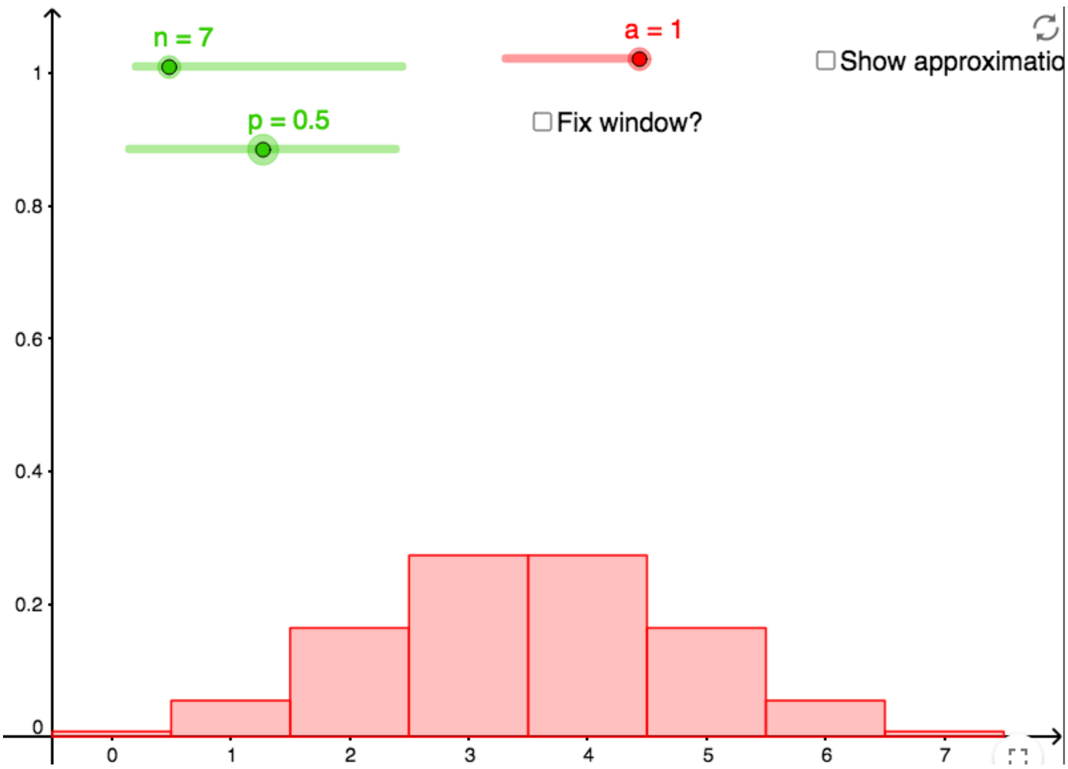

Fig. 10. Applet of binomial approximation

In particular, the mathematics shown by the applet in Figure 10 are as follows:

The central limit theorem is the tool that enables us to use the normal distribution to approximate binomial probabilities:

• let X_i = 1, if a person agrees that a particular event is occurring with probability p,
• let X_i = 0, if a person does not agree that a particular event is occurring with probability 1-p.
Let X_i is a Bernoulli random variable with mean

$$\mu = E(X) = (0)(1-p) + (1)(p) = p$$

and variance

$$\sigma^2 = Var(X) = E[(X-p)]^2 = (0-p)^2(1-p) + (1-p)^2(p) = p(1-p).$$

We conducted a research study with a random sample on n people, and let
$Y = X_1 + X_2 + \ldots + X_n$.
Y is a binomial (n, p) random variable, y = 0, 1, 2, ..., n, with mean

$$\mu = np$$

and variance

$$\sigma^2 = np(1-p)$$

In a teaching context, a teacher using GeoGebra might ask students to play with the green sliders first and explain what they noticed. After doing so, students may articulate that when n decreases, the number of columns decreases as well and that each column becomes wider (see Figure 11). Moreover, when n increases, the number of columns increases, and the columns move to the right (see Figure 12).

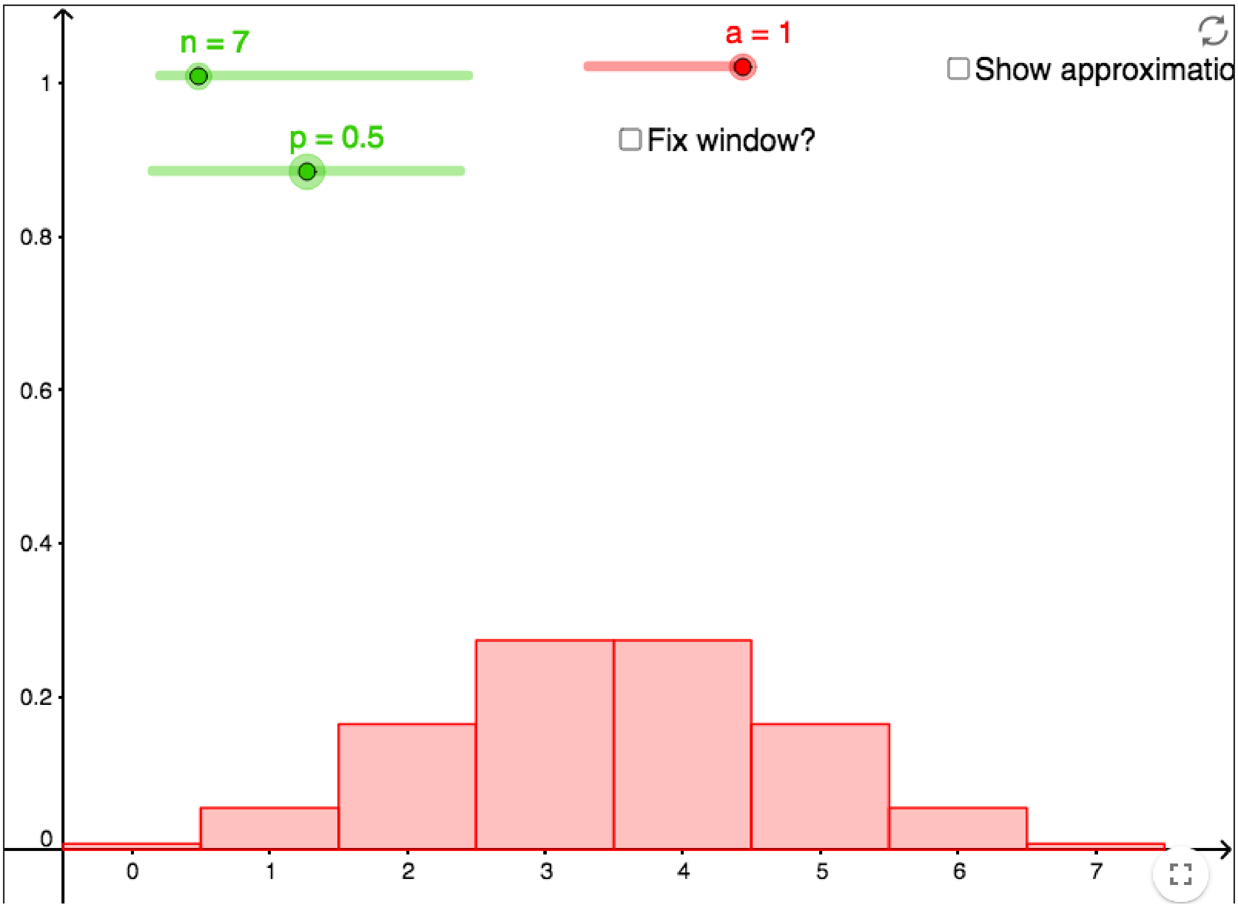

Fig. 11. When n decreases, the number of columns decreases, and the width of each column increases

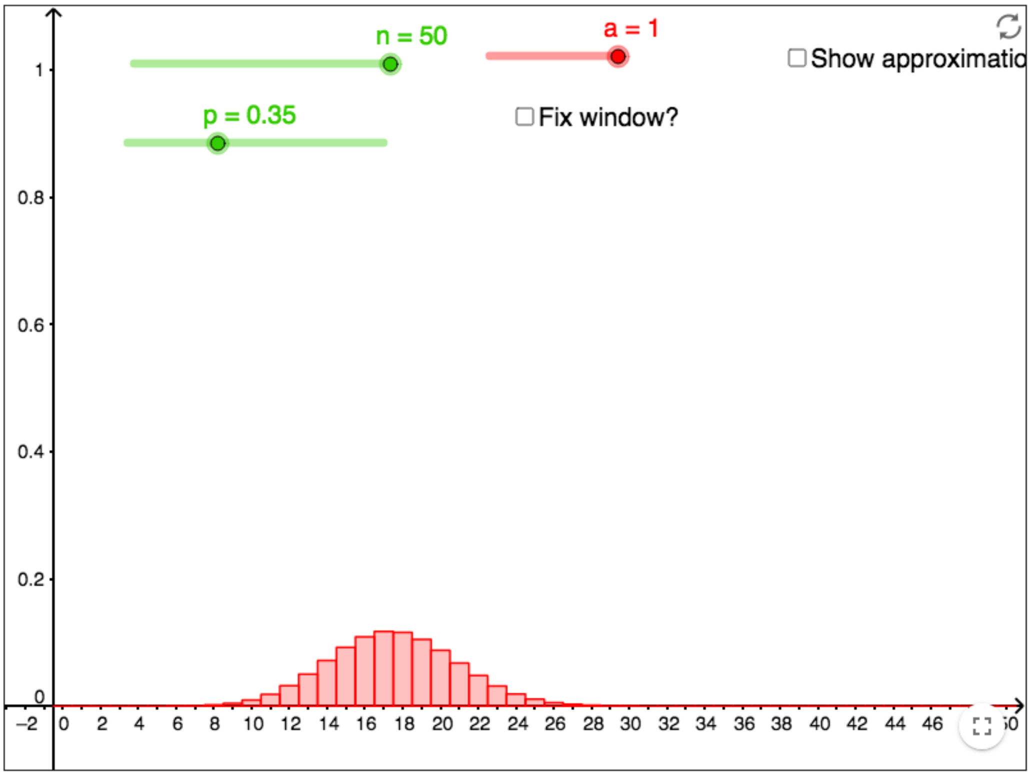

Fig. 12. When *n* increases, the number of columns increases

Students also may notice that when *p* decreases, the distribution of data moves to the left in the visualisation (see Figure 13) and that when *p* increases, the distribution of data moves to the right (see Figure 14).

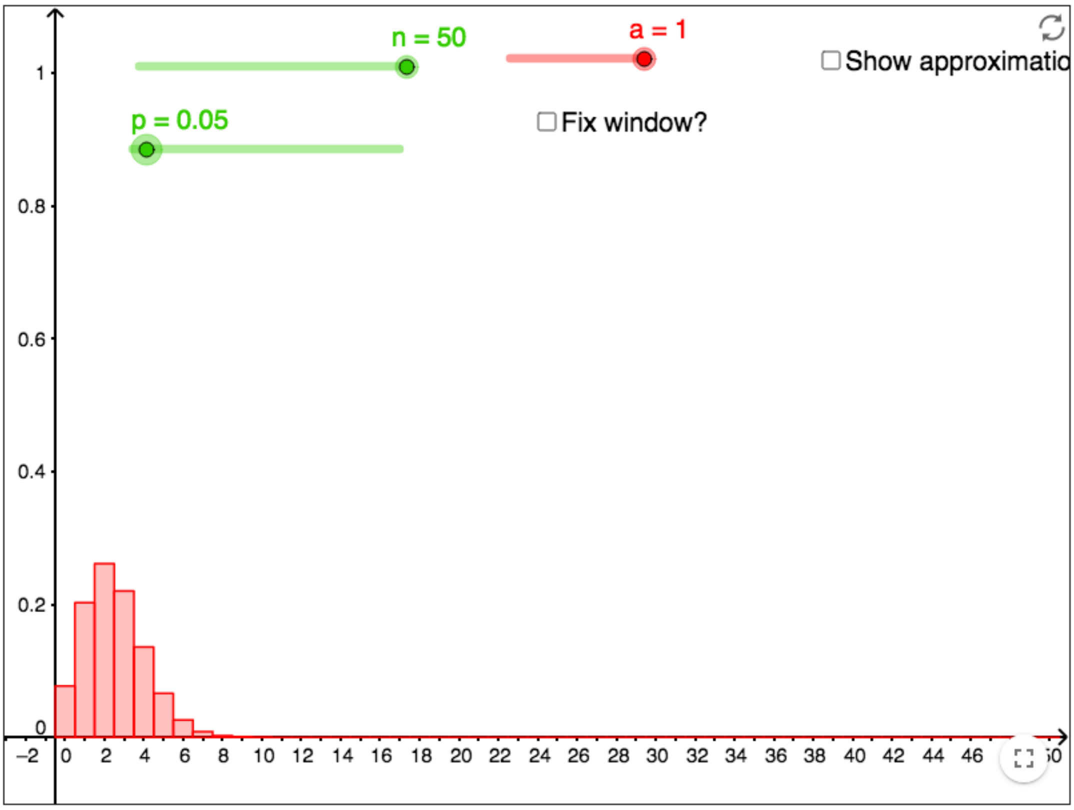

Fig. 13. When p decreases, the distribution of data moves to the left

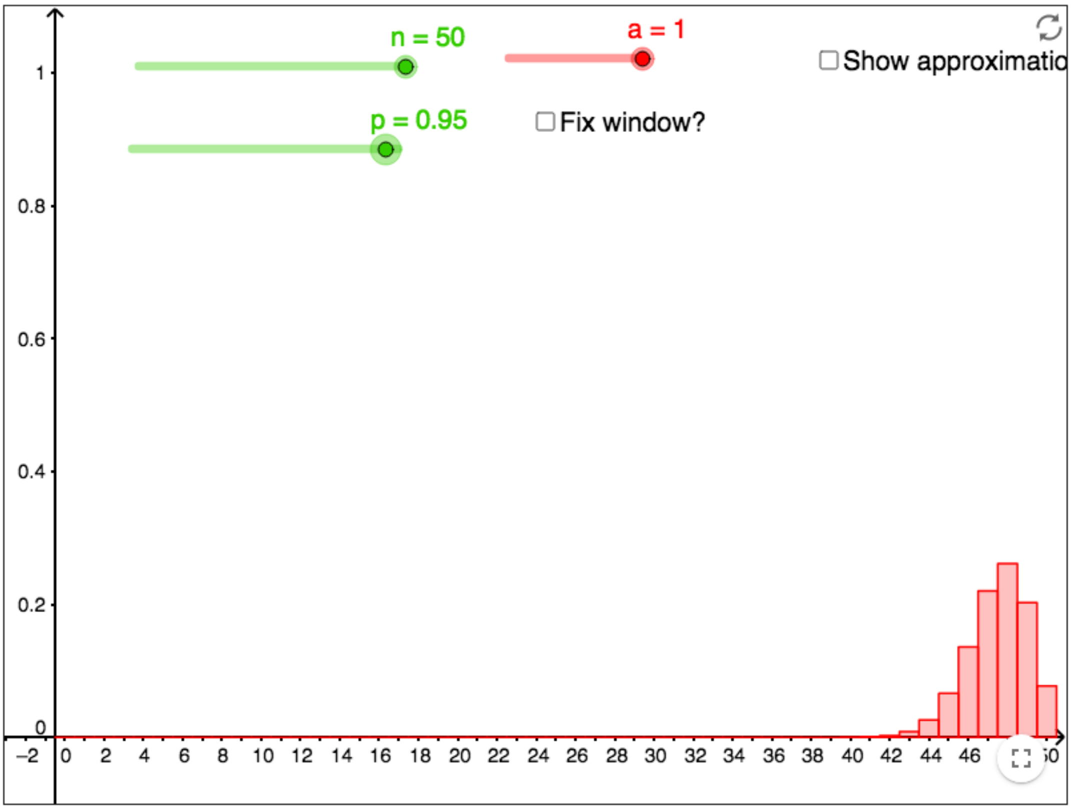

Fig. 14. When p increases, the distribution of data moves to the right

A teacher might ask students to assume that n = 10 and p = ½ (so that Y is binomial (10, ½) in order to calculate the probability that five people approve of a particular event occurring.

Students can adjust the sliders of the applet so that n would indicate 10 and p would indicate 0.5 The applet provides a visualisation of the probability that five people approve of a particular event occurring (Figure 15) – when x is equal to 5, the other coordinate on the continuous distribution is equal to 0.2460, representing a probability of 24.6 %.

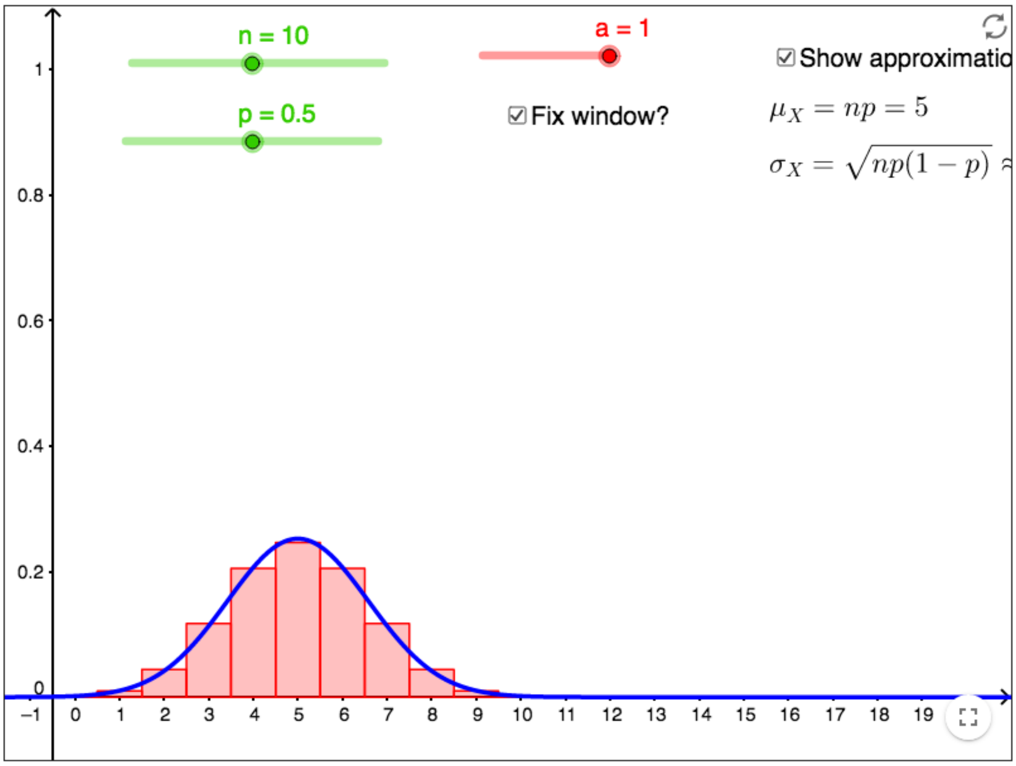

Fig. 15. When $n = 10$ and $p = ½$

In particular, when we look at the graph of the binomial distribution with the vertical column corresponding to $Y = 5$, we make an adjustment that is called a "continuity correction" by using the continuous distribution (i.e. the normal distribution*) to approximate the discrete distribution. Specifically, the column that includes $Y = 5$ also includes any Y greater than 4.5 and less than 5.5, as follows:

$$P(Y = 5) = P(4.5 < Y < 5.5) = P(4.5 < Z < 5.5)$$
$$= P\left(\frac{4.5-5.5}{\sqrt{2.5}} < Z < \frac{5.5-5}{\sqrt{2.5}}\right) =$$
$$= P(-0.32 < Z < 0.32) =$$
$$= P(Z < 0.32) - P(Z < -0.32) =$$
$$= P(Z < 0.32) - P(Z > 0.32) =$$
$$= 0.6255 - 0.3745 = 0.251$$

The visualisation of the probability that five people approve of a particular event occurring can be also determined by calculating the exact probability using the binomial table with $n = 10$ and $p = ½$. Doing so, we get

$$(Y=5)=(Y\leq 5)-P(Y\leq 4)=0.6230-0.3770=0.2460.$$

Hence, there is a 24.6 % chance that five randomly selected people approve of a particular event occurring.

Visualising the above example makes it accessible to younger students, helping them understand, interpret and use the data to calculate probabilities. Moreover, the use of applets caters to the needs of diverse learners and could help younger students construct the meaning of the co-ordination of the two epistemological perspectives on distribution (Prodromou, 2012a;

* Y is defined as a sum of independent random variables. When *n is large,* the Central Limit Theorem can be used to calculate probabilities for Y. Specifically, the Central Limit Theorem establishes that when independent random variables are added, their sum tends towards a normal distribution although the original variables themselves are not normally distributed: $Z=\frac{Y-np}{\sqrt{np(1-p)}}\rightarrow N(0,1)$.

Prodromou, Pratt, 2006) while connecting concepts of experimental probability and theoretical probability (Prodromou, 2012b).

3. Conclusion

Visualisation has many applications in the educational process, and this article presents practical examples from historical and modern mathematical contexts. Torricelli's approach to the area under a cycloid arc with software GeoGebra brings possibility to present mathematics concepts from historical materials developed by mathematicians in the past for future mathematics teachers (see Zahorec et al., 2018).

According to the theory developed by David Tall (see Tall, 2006 and Tall, Mejia-Ramos, 2009), two kinds of students exist in the classroom: one group with fast, gestalt thinking (i.e. thinking with figural characters, students see an object as a whole) and a second group that uses "step-by-step," successive thinking. Presentation of the area under the cycloid arc by Torricelli and visualisation through software makes it possible to present this topic in an appropriate way for both groups of students and to allow collaboration between them (see also the examples in Bayerl, Žilková, 2016).

Torricelli's approach has educational application in that it promotes an understanding of the area of shapes which are bordered not by a line segment but by the arc of a curve (see Moru, 2007).

Torricelli's original text uses abbreviated language, and it is difficult to translate and make a close paraphrase of some of the original text.

Many students have problems understanding, for example, the "ε-δ technique" in a purely formal way. Such students may benefit from an approach like the geometrical "ε-δ technique" presented by Archimedes and Torricelli (see Lemma II).

According to Prodromou and Lavicza (2015), GeoGebra allows for the presentation of many mathematical concepts in instrumental, relational and formal modes, with the support of visualisation and simulation.

Archimedes' approach to the area under the arc of parabolas was not only an inspiration for Torricelli but also for Slovak-Australian mathematician Igor Kluvanek, who developed his own integration theory on the exhaustion method from Eudoxos (see Nillsen, 2011).

The examples provided in this article show that the possibilities of using visualisations to display selected mathematics concepts are extensive and that such visualisations can motivate teachers to embrace the necessary technology and improve the experience of mathematics and statistics, both for themselves and their students.

The importance of technology like GeoGebra, which enables students to build their own representations and explore different aspects of those representations, must be emphasised.

Pratt, Davies, Connor (2011) discuss some general impediments to the use of technology for teaching statistics:

1. teachers not prioritising technological tools,
2. the curriculum not supporting the use of technology,
3. assessment not encouraging the use of technological tools,
4. teachers' unwillingness to attend professional development programs or up-skill on the latest technology developments, and
5. the use of technology reinforcing other skills (e.g. computation) rather than the development of concepts.

Digital technology is being introduced into many school curricula, and "visualisation has blossomed into a multidisciplinary research area, and a wide range of visualisation tools have been developed at an accelerated pace" (Prodromou, Dunne, 2017a: 1). In such an environment, it is hoped that the barriers noted by Pratt, Davies and Connor (2011) can be overcome.

In particular, research on data visualisation and statistical literacy (Prodromou, Dunne, 2017b) has discussed the role of visualisation and the need for teachers "to marshal many facets of visualisation, from elicitation of pattern to salient pictorial representation of a particular specified context" (Prodromou, Dunne, 2017b: 3). They found that visualisation assists with the basic production of contextual meaning and interpretation compared to other familiar cognitive strategies, including the following: describing and comparing observed conditions or states in a context; describing and assessing relationships amongst categories; counts and measures (often with time factors ignored); describing and comparing current changes or processes in a context (over a period, sometimes with equal inter-observation intervals); and describing and assessing associations amongst changes in observed variables (over some implicit or specified time intervals).

Prodromou and Dunne suggested (see (Prodromou and Dunne, 2017a) that fluency with visualisation is central to statistics. We would expect the same to be true in mathematics, but unfortunately, no research about the process of understanding through visualisations of mathematical concepts has been done.

This paper's demonstration of the role of GeoGebra in presenting Torricelli's proofs suggests ways in which current technologies and visualisation can be integrated into learning. Future research should experiment with GeoGebra visualisations as an aid to teaching integration (i.e. calculating the area under a curve).

7. Acknowledgements

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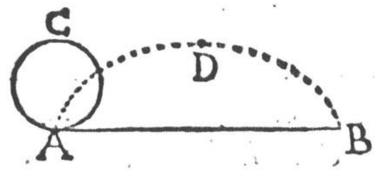
Appendix 1. Original Latin text of Torricelli's Appendix

85

APPENDIX
De Dimensione Cycloidis.

LIBET hic appendicis loco addere solutionem problematis non iniucundi, & si materiã, propositionemque spectes, primo intuitu difficilimi. Torsit hoc, fefellitq. pluribus ab hinc annis Mathematicos nostri seculi primarios; frustra enim tentata demonstratio euasit ab illorũ manibus ob fallaciam experientiæ. Appensis namque ad libram manufactam spatijs figurarum materialibus, nescio quo fato, ea proportio quæ verè tripla est, semper minor quã tripla apparuit. Vnde factum est, quòd potius ob suspicionem incommensurabilitatis (vt ego credo) quàm ob desperationem demonstrationis, instituta contemplatio ab illis dimissa sit.

Suppositum est huiusmodi. Concipiatur super manente aliqua recta linea ab. *circulus* ac, *contingens rectam* ab. *in puncto* a. *Noteturq; punctum* a, *tamquã fixum in peripheria circuli* ac. *Tum intelligatur super manente recta* ab. *conuerti circulum* ac, *motu circulari simul & progressiuo versus partes* b: *ita vt subinde aliquo sui puncto rectã lineã* ab *semper contingat, quousq. fixum punctum iterum ad contactum reuertatur, puta in* b. *Certum est, quòd punctum* a *fixum in peripheria circuli rotantis* ac, *aliquam lineam describet, surgentem primò à subiecta linea* ab, *deinde culminantem versus* d; *postremo pronam, descendẽtemque versus punctum* b.

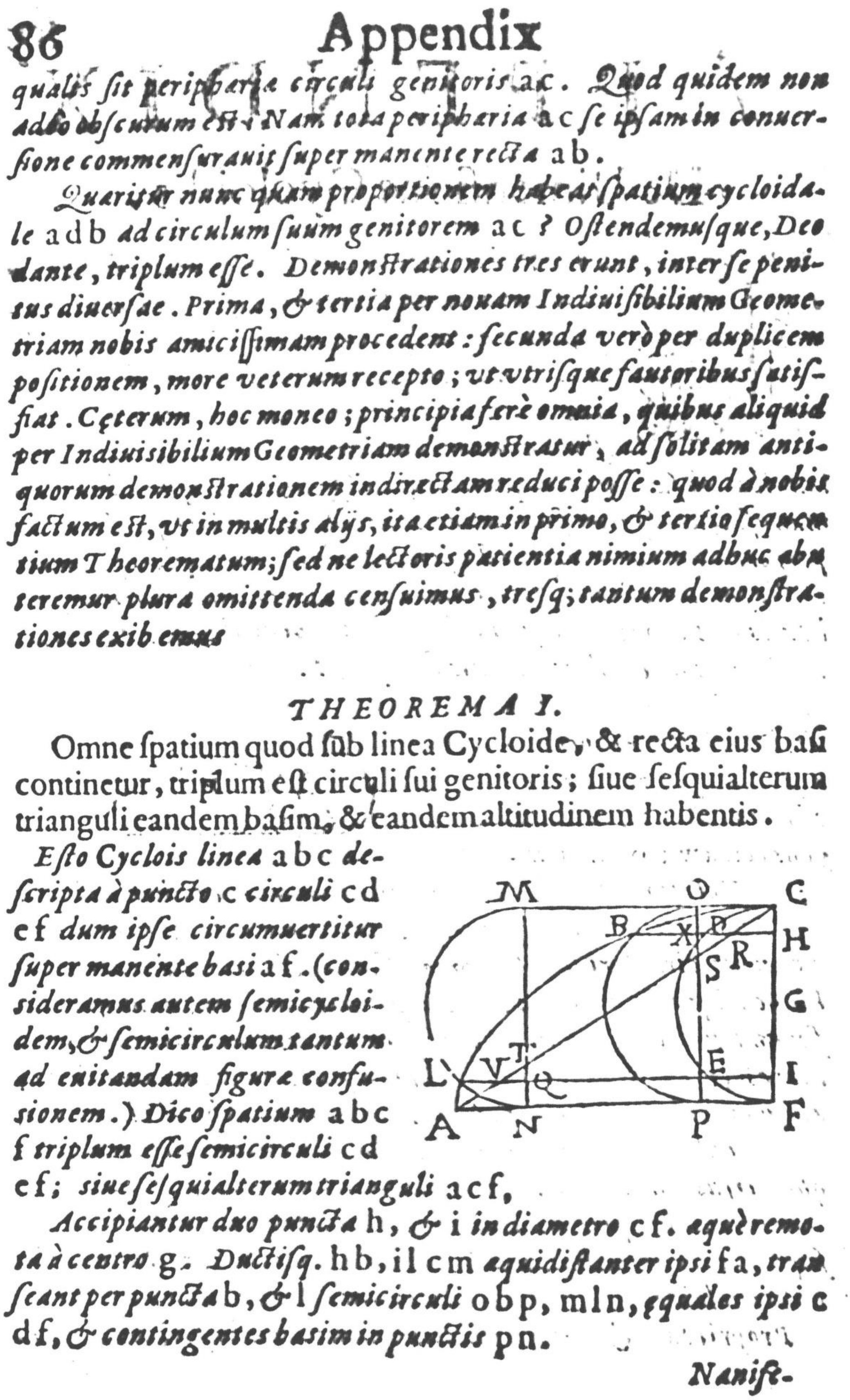


Vocata est à prædecessoribus nostris. Præcipue à Galileo iam supra 45. annum, huiusmodi linea adb. *Cyclois, recta verò* ab. *basis cycloidis; At circulus* ac, *genitor cycloidis.*

Proprietas, & natura cycloidis ea est, vt basis ipsius ab. *æ-*

qualis

Fig. 16. Page 85 of Torricelli's manuscript



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qualis sit peripharia circuli genitoris ac. Quod quidem non adeo obscurum est: Nam tota peripharia ac se ipsam in conuersione commensurauit super manente recta ab.

Quaeritur nunc quam proportionem habeat spatium cycloidale adb ad circulum suum genitorem ac? Ostendemusque, Deo dante, triplum esse. Demonstrationes tres erunt, inter se penitus diuersae. Prima, & tertia per nouam Indiuisibilium Geometriam nobis amicissimam procedent: secunda verò per duplicem positionem, more veterum recepto; vt vtrisque fautoribus satisfiat. Ceterum, hoc moneo; principia ferè omnia, quibus aliquid per Indiuisibilium Geometriam demonstratur, ad solitam antiquorum demonstrationem indirectam reduci posse: quod à nobis factum est, vt in multis alijs, ita etiam in primo, & tertio sequentium Theorematum; sed ne lectoris patientia nimium adhuc abuteremur plura omittenda censuimus, tresq; tantum demonstrationes exibemus

THEOREMA I.

Omne spatium quod sub linea Cycloide, & recta eius basi continetur, triplum est circuli sui genitoris; siue sesquialterum trianguli eandem basim, & eandem altitudinem habentis.

Esto Cyclois linea abc descripta à puncto c circuli cd ef dum ipse circumuertitur super manente basi af. (consideramus autem semicycloidem, & semicirculum tantum ad euitandam figurae confusionem.) Dico spatium abc f triplum esse semicirculi cd ef; siue sesquialterum trianguli acf,

Accipiantur duo puncta h, & i in diametro cf. aequè remota à centro g. Ductisq. hb, il cm aequidistanter ipsi fa, transeant per puncta b, & l semicirculi obp, mln, equales ipsi cdf, & contingentes basim in punctis pn.

Nanif-

Fig. 17. Page 86 of Torricelli's manuscript

De Cycloide. 87

Manifestum est rectas hd, ie, xb, ql *aequales esse, per 14 Tertij, aequalesq. erunt arcus* ob, ln. *Item cum ęquales sint* ch if, *ęquales erunt* cr, ua *ob parallelas*.

Tota peripheria mln, *ob cycloidem, aequalis est rectę* af. *itēque arcus* ln *rectae* an *ob eandem causam, cum arcus* ln *seipsum super recta* an *commensurauerit; ergo reliquus arcus* lm, *reliqua rectę* nf *ęqualis erit. Eadem ratione arcus* bp *rectę* ap, *& arcus* bo *rectę* pf, *aequalis erit*.

Iam recta an *aequalis est arcui* ln, *siue arcui* bo, *siue rectę* pf. *Ergo ob parallelas, ęquales erunt* at, fc. *Verum quia aequales erant etiam* cr, au. *reliquę* ut, fr *ęquales erunt. Propterea in triangulis aequiangulis* utq, rfx, *aequalia erunt latera homologa* uq, xr. *Patet itaque quod duae rectae* lu, br *simul sumptae aequales erunt duabus rectis* lq, bx, *nempe ipsis* ei, dh, *& hoc semper verum erit vbicunq. sumantur duo puncta* h, *&* i, *dumodo aequaliter a centro sint remota. Ergo omnes lineae figurae* albca *aequales sunt omnibus lineis semicirculi* cdef; *& ideò figura bilinearis* albca *aequalis erit semicirculo* cdef.

Sed triangulum acf *duplum est semicirculi* cdef. *(nam triangulum* acf *reciprocum est triangulo Propos. pr. Arch. de dimens. circ. cum latus* af *semiperiphaeriae, latus verò* fc *diametro sit aquale, vnde sequitur triangulum* acf *aequale esse integro circulo cuius diameter sit* cf.). *Ergo componendo, totum cycloidale spatium sesquialterum erit trianguli inscripti* acb; *Triplum verò semicirculi* cdef. *Quod erat*.

Lemma I.

Si ſuper lateribus oppoſitis alicuius rectanguli AF duo ſemicirculi deſcripti ſint, EIF, AGD, erit figura ſub periphærijs, & ſub reliquis lateribus comprehenſa ęqualis prędicto rectangulo.

Vocetur autem talis figura Arcuatum; tam si fuerit integra, quàm etiam ipsius partes; quando secta fuerit à linea ipsi fd *parallela*.

Demon-

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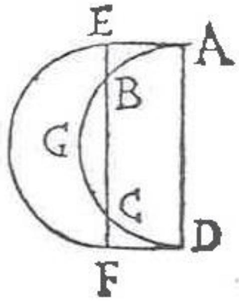
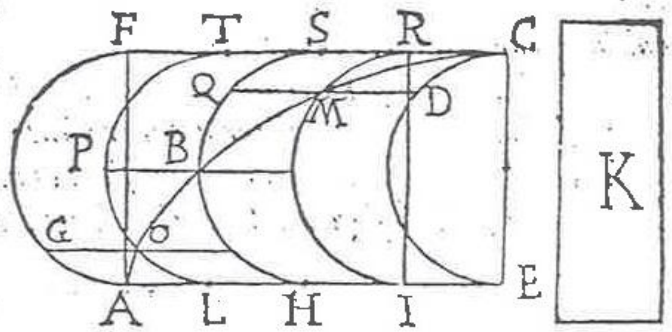
Demonstratur; quoniam cum sint aequales semicirc. dempto communi segmento b g c, *additisque communibus trilineis* e b a, c f d. *clarum erit propositum.*



Quando verò detur casus quod segmentum nullum sit, tunc breuior facilior q; demonstratio erit. Facilè etiam per eandem prosthaphaeresim ostenditur arcuatum sectum à linea ipsi fd *parallela equale esse rectangulo aequealto, & super eadem basi constituto.*

Lemma II.

Esto linea cycloidalis a b c *descripta à puncto* c *semicirculi* c d e *dum conuertitur super manente* a e. *Compleatur rectangulũ* a f c e, *fiatq. circa diametrum* a f *semicirculus* a g f. *Dico cycloidem* a b c *secare bifariam arcuatum* a g f c d e.



Si enim ita non est, erit vtiq. alterum ex duobus trilineis f g a b c, a b c d e, *magis quam dimidium eiusdem arcuati. Esto & ponatur alterum ex ipsis (quodcunq. sit) puta* a b c d e *maius quàm dimidium arcuati. Sitq. excessus, quo trilineum superat semissem arcuati, aequalis spatio cuidam* K.

Secetur bifariam a e *in* h; *& iterum* h c *in* i; *& sic fiat semper donec rectangulum aliquod* i e c *minus reperiatur spatio* K. *Tunc diuidatur integra* a e *in particulas aequales ipsi* i e, *& per puncta diuisionum* l, h, i, *transeant semicirculi aequales ipsi* c d e *semicirculo, tangentes basim in punctis* l, h, i. *secantesq. cycloidem in* o, b, m, *per quae puncta agantur rectae* g o, p b, q m d *aequidistantes basi* a e.

Eri

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De Cycloide. 89

Erit itaque arcuatum oh *ęquale ipsi* gl: *arcuatum verò* bi *ęquale arcuato* ph: *& arcuatum* me *aequale arcuato* qi. *Propterea vniuersa figura inscripta in trilineo* abcde *constans ex arcuatis, ęqualis erit figurae eidem trilineo circumscriptę, excepto tamen arcuatò* imrcde. *Quod si figurae circumscriptae addas suum arcuatum* imrcde, *superabit circumscripta figura ipsam inscriptam excessu praedicti arcuati, siue rectangulo* re, *nempe minori excessu quam sit spatium* K. *Propterea inscripta in trilineo figura adhuc erit plusquàm dimidium arcuati* agfcde.*& ideo maior quam trilineum* fgabc. *Sed eadem aequalis est alteri figurę ex arcuatis compositę & in trilineo* fgabc *descriptae*: *ostenditur infra* *ergò hęc inscripta figura maior esset suo trilineo* fgabc. *pars suo toto. quod esse non potest.*

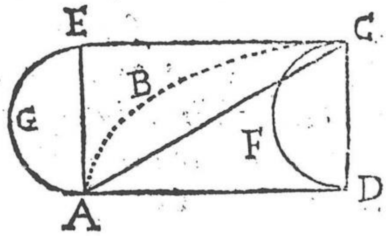
Quod inscriptae figurae sint ęquales patet. Nam arcus ol *ęqualis est rectae* la, *hoc est rectae* ie, *hęc est arcui* rm (*ob cycloidem.*) *Ergo arcuatum* oh *aequale erit arcuato* mf. *& sic de singulis.*

Si verò supponeremus trilineum fgabc *maius quàm dimidium arcuati* agfcde, *constructio figurae, & demonstratio penitus eadem erit. Ergò concludemus cycloidem lineam* abc *bifariam secare arcuatum* agfcde. *Quod erat propositum.*

THEOREMA II.

Spatium cycloidale triplum est circuli sui genitoris.

Esto cyclois abc *descripta à pũcto* c *circuli* cfd. *dico spatium* abcd *triplũ esse semicirculi* cfd.

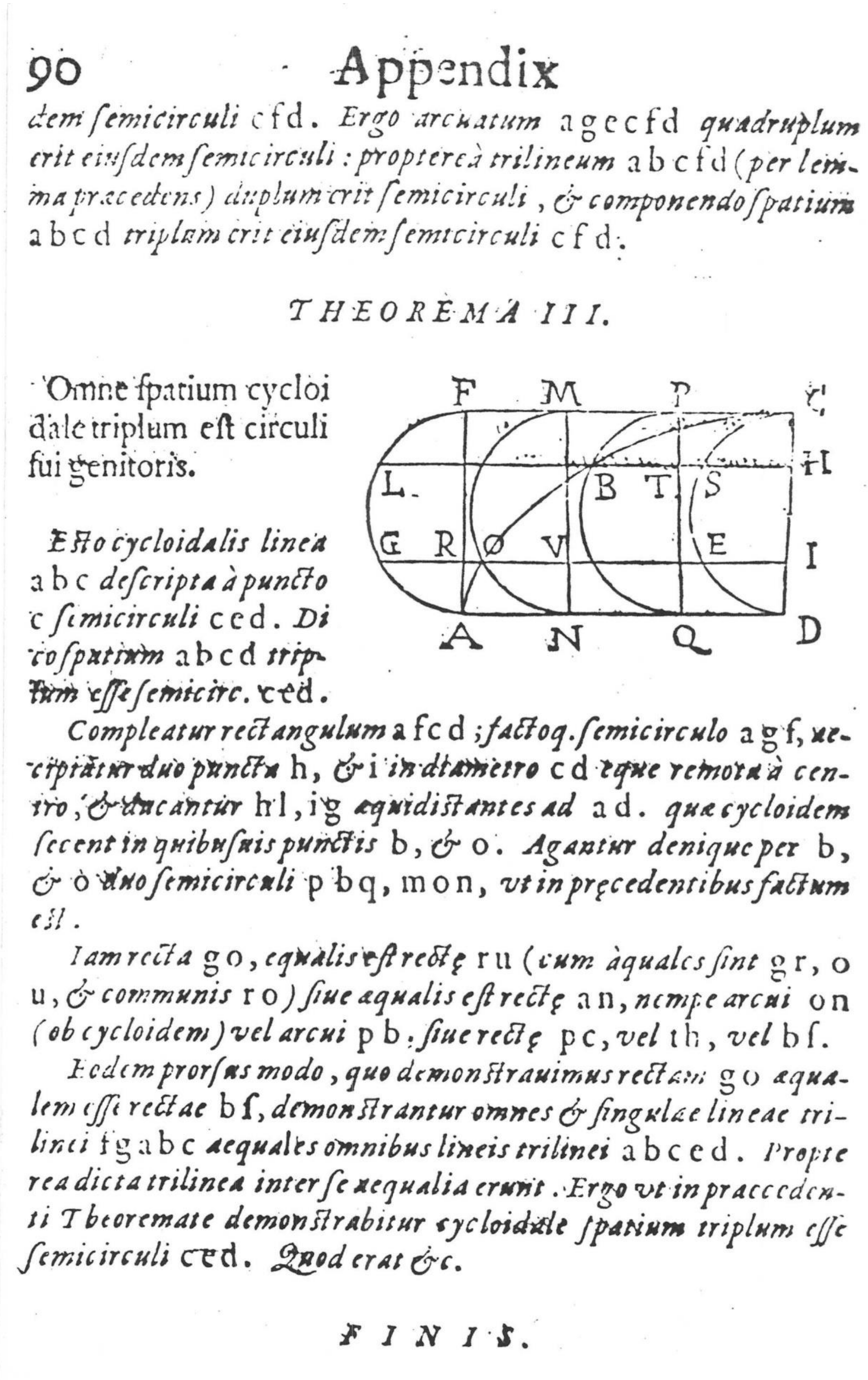


Compleatur rectangulum adce; *factoq. super* ae *semicirculo* age, *ducatur* ac.

Triangulum adc *duplum est semicirculi* cfd (*nam basis* ad *aequalis est periphaeriae* cfd *ob cycloidem, altitudo verò* dc *aequalis diametro*) *ideò rectangulum* ed *quadruplum erit eius-*

M dem

Fig. 20. Page 89 of Torricelli's manuscript



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dem semicirculi c f d. Ergo arcuatum a g e c f d quadruplum erit eiusdem semicirculi: propterea trilineum a b c f d (per lemma praecedens) duplum erit semicirculi, & componendo spatium a b c d triplum erit eiusdem semicirculi c f d.

THEOREMA III.

Omne spatium cycloidale triplum est circuli sui genitoris.

Esto cycloidalis linea a b c descripta à puncto c semicirculi c e d. Dico spatium a b c d triplum esse semicirc. c e d.

Compleatur rectangulum a f c d; factoq. semicirculo a g f, accipiantur duo puncta h, & i in diametro c d aeque remota à centro, & ducantur h l, i g aequidistantes ad a d. quae cycloidem secent in quibuslibet punctis b, & o. Agantur denique per b, & o duo semicirculi p b q, m o n, vt in praecedentibus factum est.

Iam recta g o, equalis est rectae r u (cum aequales sint g r, o u, & communis r o) siue aequalis est rectae a n, nempe arcui o n (ob cycloidem) vel arcui p b: siue rectae p c, vel t h, vel b s.

Eodem prorsus modo, quo demonstrauimus rectam g o aequalem esse rectae b s, demonstrantur omnes & singulae lineae trilinei f g a b c aequales omnibus lineis trilinei a b c e d. Propterea dicta trilinea inter se aequalia erunt. Ergo vt in praecedenti Theoremate demonstrabitur cycloidale spatium triplum esse semicirculi c e d. Quod erat &c.

FINIS.

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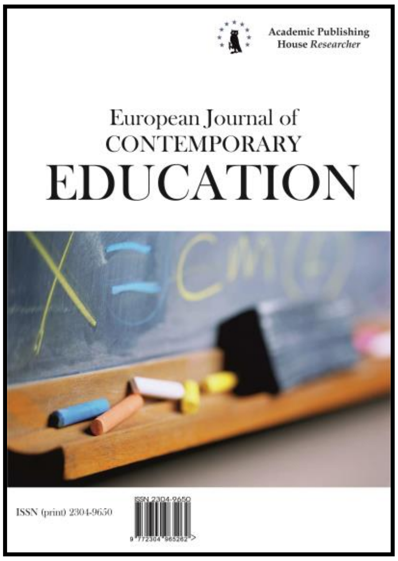

Visualisation in Basic Science and Engineering Education of Future Primary School Teachers in Human Biology Education Using Augmented Reality

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Abstract

New technologies with a modern method of teaching must be implemented in university studies, and an important part is teacher training study. These technologies make study more attractive for students and bring greater motivation to an understanding of notions. The main focus of this study is visualisation in science and engineering education using augmented reality in the context of biology education based on constructivist and constructionist concepts. We present in our contribution augmented reality technology as a part of using mobile technologies in biology education for future primary school teachers. The study is focused on perception of this method by future primary teachers who will teach biology as one of the areas of primary education and who were also the subjects of the research. We also mention two already existing biology-themed augmented reality applications, which appear to be interesting, enhancing and beneficial in the context of biology education. The findings of the study confirmed, using this method, that the students' understanding was deeper, their motivation was greater, and, last but not least, their creativity was strongly supported. The students were motivated by the new method, they cooperated very well and learning was constructive.

Keywords: visualisation, augmented reality, constructivism, constructionism, anatomy, digital technology, teacher training, pre-service teachers, primary level of education.

1. Introduction

The technological and social changes related to using mobile devices brings the question, how is it possible to implement these technologies into the educational process? Typical examples of the devices used for mobile learning include cell phones, smartphones, palmtops, and handheld computers; tablet PCs, laptops, and personal media players can also fall within this scope (Ferko, Koreňová, 2015). Sharples (2009) presented different views of defining mobile learning. Current perspectives on mobile learning generally fall into the following four broad categories:

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1. Technocentric. This perspective dominates the literature. Here, mobile learning is viewed as learning using a mobile device, such as a PDA, mobile phone, iPod, PlayStation Portable, etc.;
2. Relationship to e-learning. This perspective characterises mobile learning as an extension of e-learning;
3. Learner-centred;
4. Augmenting formal education.

Using mobile technology and the subsequent visualisation of abstract concepts, we can make it easier for students to zoom in and demonstrate the subject matter of complex subjects. At present, students meet with visualisation every day in the form of visual TV images and video games. In contrast, the standard form of teaching is passive and is not exciting for them. But through the simple technique of visualisation, we can transform students from passive learners to active teachers. Visualisation can help students improve their understanding of the subject's curriculum (Puett Miller, 2004). One of the methods of mobile learning that allow us to demonstrate the visualisation of a given subject is Augmented Reality.

The term Augmented Reality (AR) was created around the year 1990 and it presents virtual images in the real world, i.e., the reality is augmented of virtual elements. The integration of such images is made by the use of Information and Communication Technologies (ICT), through a mobile device with a camera (tablet or mobile phone with android system), which provides access to the environment of AR. Further, the development of AR content encourages higher learning autonomy and supports mobile-learning. Besides, the exploration of ICT by students can promote collaboration, innovation and creativity skills (Coimbra et al., 2015). Augmented reality is the supplementation of the reality perceived by the user with virtual elements. The use of mobile AR technology applications allows the work of educators to be made more effective, and in addition, it enables pupils to become actively involved in the education process (Azuma et al., 2001; Gunčaga, Janiga, 2016; Krawczyk-Stańdo et al., 2013).

AR technology helps the student to gain improved access to the subject because it mobilises the learning environment and allows learning flexibility. In addition, AR technology features support students in learning complex subjects in general; in particular, the subject of human anatomy as one part of biology education. Human anatomy involves learning anatomy in the practical dissection laboratory, with exposure to the structure of the human body and internal organs (Farlex, 2014). The practical session facilitates students to learn more complex parts of the body structure. Nevertheless, after the practical sessions, most students have difficulty repeating the information from this subject. Ganguly (2010) states that human anatomy didactic lectures followed by practical dissections could not generate long-lasting understanding of the subject, while AR applications had a positive impact on students' understanding of the content, as well as memory retention. When speaking about AR application in more detail, the visualisation of the internal structures may serve as a stronger memory trigger for students (Radu, 2014).

AR visualisations not only eventually improve students' knowledge of the subject of human anatomy, but also improve clinical skills in the laboratory (Garrett et al., 2015). Garrett and et al. (2015) found that students' knowledge acquisition, self-directed learning, and laboratory skills improved by using AR technology. Carlson and Gagnon (2016) similarly describe the use of AR technologies to improve clinical skills. They use the ARISE (Augmented Reality Integrated Simulation Education) system, which enables virtual clinical scenes to be set up for students to diagnose virtual patients. It is a system used in the education of medical students. The ARISE system is an innovative way to enhance simulation in learning clinical skills, provide authentic interactions, and potentially assist learning (Carlson, Gagnon, 2016).

One of the applications focused on the human body (male and female) is **Anatomy 4D,** which enables students to experience the interactive 4D environment of human anatomy. In this application, it is possible to view all the systems simultaneously and separately. It reveals the spatial relationships of the individual internal organs and enables students to understand the physiological processes that arise between and within individual organs. It is also very good to see the detailed structure of the organs themselves. Based on the abovementioned facts, this simple learning environment is good for use in the classroom and is widely used by teachers, students, medical professionals, and medical practitioners. Through this application, biology tutors can visualise one of the most complex systems, human anatomy (Anatomy 4D, 2018).

Further to the application that explores human anatomy in general, we will now consider an application that focuses just on parts of the human body. The **Brain iExplore AR** application provides detailed information about the brain. This AR application shows how the brain reacts to sounds, as well as the upside-down images of the world that the eyes actually see before the visual cortex of the brain processes them. Through this application, it is possible test fine motor skills and find what part of the brain deals with short-term memory in the matching pairs game (The Brain iExplore AR, 2018). The environments of both AR applications we used in our study are illustrated in Figure 1.

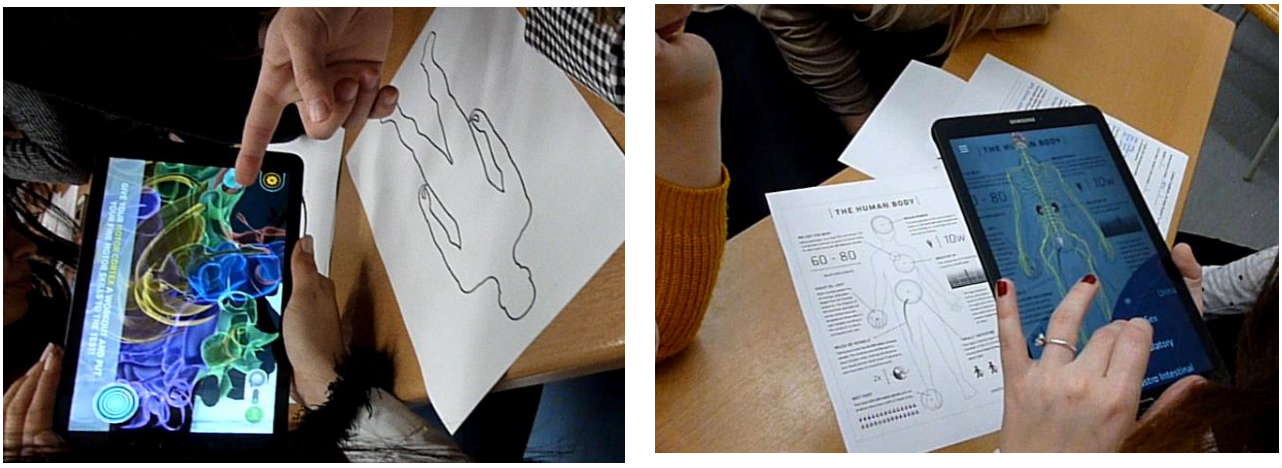

Fig. 1. Students represent the anatomical parts of the neural and endocrine system with the augmented application “The Brain iExplore” and “Anatomy 4D”

It is extremely motivating for students if we make fields more comprehensible for them with the aid of augmented reality, as some can be difficult to understand, such as the anatomy and physiology of neural and endocrine system. These applications are free of charge and the markers can be also printed free of charge. They work in a similar way as the AR Flashcard Shapes, which is good for increasing users’ motivation.

The inductive (constructivist) approach in teaching, compared to a deductive approach, is characterised by distinctly different characteristics (Kostrub, 2008, 2016, 2017a, 2017b). The constructivist theory of learning assumes that each person creates himself, and constructs his own knowledge of the world in which he lives. Constructivism tries to overcome the transmissiveness of traditional teaching – the transfer of “teachers’” knowledge to the students. It deals with learning and understanding (Stoffová, Štrbo, 2016; Tóthová et al., 2017).

An increasing number of researchers have come to the following view: the knowledge is essentially “situated” and is not detached from the situations in which it is constructed and actualised. This growing interest in the idea of situated knowledge, or knowledge as it lives and grows in context, has led many researchers to look closely at individual people’s ways of knowing, or relating. Constructionism is an educational theory that has many applications in the digital school environment (Kostrub, Severini, 2017; Sabelli, 2008**Ошибка! Источник ссылки не найден.**).

The root for constructionism was constructivism. Constructivist instructional design, according Kalaš (2013), aims to provide generative mental constructions embedded in relevant learning environments that facilitate knowledge construction by learners. The constructivist approach has many applications in different areas (Kalaš, Winczer, 2008). In the following research, we used these pedagogical theories, because students – pre-service teachers for primary level work with different applications used augmented reality. These applications were tools for a better understanding of the base anatomical notions.

2. Materials and Methods

We conducted the research in a group of 61 students in their first year of the bachelor study in the teacher training program for future teachers in primary level. The pedagogical experiment was realised in November 2017 at the Faculty of Education at Comenius University in Bratislava.

Our research focused on analysing the use of mobile technology and manipulation activities in teaching biology based on constructivist and constructionist concepts. We looked into the problem of how to incorporate the use of tablets in education. We believe that using this method, the students' understanding is deeper, their motivation is greater, and, last but not least, their creativity is strongly supported. The AR applications "The Brain iExplore" and "Anatomy 4D" were installed with cards on tablets (Figure 2).

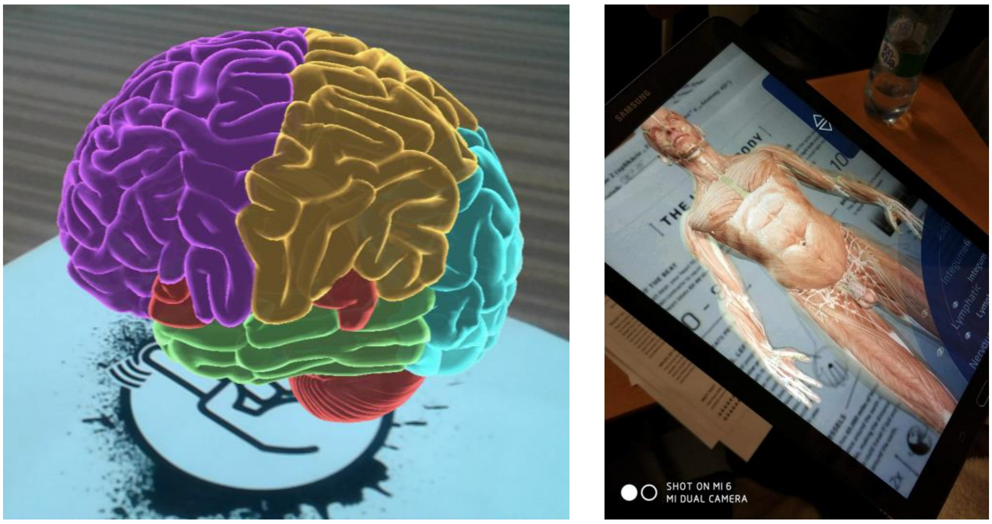

Fig. 2. Applications "The Brain iExplore" and "Anatomy 4D"

Some students used the books of anatomy and smartphones (internet) for solving the tasks (Figure 3).

Fig. 3. Student working with book of anatomy and with smartphones

Students worked in groups of 3 or 4 persons (17 groups) during the lesson, using the constructive method. In the course of the qualitative research, we researched to observe the effect of the AR applications "The Brain iExplore" and "Anatomy 4D" on learning in a constructivist environment. Using these applications on the tablet, they can use AR to study the anatomy of neural and endocrine systems that appear in three dimensions. The students worked with neural and endocrine systems to understand neurohumoral regulation of growth and development during the lesson of "somatic child development". The task for the students was to identify parts of the brain in the "Brain iExplore" application and to describe their function, and in the application "Anatomy 4D" to identify endocrine glands in individual anatomical systems. Every group obtained two cards, one for the “Brain iExplore” application and one for the “Anatomy 4D” application. They worked for 60 minutes. A particularly interesting part of the research was to see how students tried to find those parts of the neurohumoral system on the internet or in the anatomy book, which were unknown to them. Some students tried to translate the English names of anatomy systems to Slovak on the internet. At the end of the lesson, students submitted a protocol (one for each group).

Our qualitative pedagogical research relies on the description of the teacher's observations and on the video recording of the students’ work. The interest of students in this type of teaching method was verified by an electronic questionnaire. Each student completed a questionnaire. The questionnaire contained 10 closed questions. The first six questions in the questionnaire revealed the real interest of the students in the applications of augmented reality in the biology lesson, and whether this form of teaching helped them to better memorise anatomy information. The other four questions focused on the students’ view of using smartphones and tablets during the biology lesson, because augmented reality applications can only by these technologies. For nine questions, students were given one choice of answer. Only in question number 8, "How do you use a smartphone/tablet while you study?", can students choose more answers. All answers to the questions were evaluated in percentages.

3. Results

Through the use of the open coding method and video-recording transcription, we defined three categories and their sub-categories, which are summarised in the following table:

Table 1. Categories of students’ activities

CATEGORY	SUBCATEGORY	EXPRESSIONS AND ACTIVITIES
1. Students´ mutual learning – constructionist approach	1. Students support each other	We could determine it; We will see how it can be done...; We will try it this way; We need to find out what it is; We should try it; We solved it
	2. Mutual learning helps them to understand terms and relations	You have to come and see; You can set up your tablet so we can see it; I do not understand it, and can you explain it to me?; You will not see these parts of the brain on the tablet, because...; Try to give something else to compare it
	3. They do not collaborate with each other	I think...; I will overwrite it; I do not see anything there
2. Influence of mobile technology	1. Mobile technology helps them understand human anatomy	There is an emphasis on the whole body; The middle brain is the smallest; This purple and yellow part has two hemispheres; There are no pathways of the nervous system; It will be the whole brain stem; We found the pancreas in the digestive system
	2. Thanks to mobile technology, they recognise the different nomenclature of anatomical parts	Do you know how to say it in Slovak?; Do you know how to say it in English?; Pons is the bridge; Cerebellum is the brain; The pituitary gland is “hypophysis”; Skeletal is the skeleton
	3. It helps them when they can make several attempts thanks to the technology	I have several attempts, several solutions; I can correct myself; Try it differently
3. Manipulation	1. Improving	When you set up a tablet like this, you see...; Look

activities	manipulation ability by mobile technology	at it from the side; Try to go closer to see...; Try to zoom it; Something click there; The "eye" means we see them; Here you can choose something; Are you looking at the internet?
	2. Students are more motivated	It would be interesting if...; I fall off, it is good; Try it too; We solved it; We are wise; I already understand it now
	3. Disinterest of mobile technology	That's weird; That's disgusting; That's awful; It is not working; I do not know; It does not matter

The defined categories referred to constructionist teaching and the students' manipulation activities. Constructionist teaching takes place through didactically considered but conceptually open teaching activities, and through discourse (controlled argumentation, handling facts) in the form of individual as well as group exploration (learning groups), thanks to which common knowledge and understanding is established. The categories we defined were given names expressing the best given group of related expressions. Having grouped and identified data in this way, we tried to understand and evaluate them from our perspective.

The first task of the students was to recognise the colour of anatomical parts of the brain in the "Brain iExplore" application. Students recognised only a few parts of the brain through AR. Only five groups correctly recognised all the parts of the brain that the app offered. One group had the problem of determining which part of the brain is front and back. It was interesting when some students revealed some inner parts of the brain in the application. In this application, the brain was moving, changing colours, and the work with this application was therefore more challenging for students. A smaller interest in this app has also confirmed the question, "Which application did you like more?" The application "Anatomy 4D" was liked by 91.8 % of students. The application "Brain iExplore" was liked by 8.2 % of students (Table 2).

Table 2. Answers to question 1

Which application was more interesting for you?		
The Brain iExplore	5	8.2%
Anatomy 4D	56	91.8%

Some groups had almost no interest in completing the role, which contained the question about function of the individual parts of the brain. However, especially when completing this task, students collaborated most and did not hesitate to use other sources to fill the task (anatomy book or smartphone, internet). Through the transcription of the video-recordings and structured observations, we found that the students frequently helped each other. In most cases, they used the plural form when they talked to each other, which means that the students did not consider their tasks to be individual (Table 1, category no. 1, subcategory no. 1). This exercise was a repetition of the curriculum at the end of the semester in terms of the understanding of neurohumoral regulation of growth and development. We were surprised when students did not want to fill the task. 83.6 % of students admitted that they received new information through mobile technology (Table 3). Finally, it is worth noting that up to 95.1 % of students recognised that mobile technology helped them to repeat the lesson and helped them understand human anatomy (Table 4 and 5). Table 1 (category no. 1, subcategory no. 2) shows the cooperation of the students was quite clear. During the classes, they explored together, they determined interconnections and helped each other with understanding the topic. The constructivist environment established by us significantly helped the students in their work and students' mutual teaching with the help of a constructivist and constructionist approach.

Table 3. Answers to question 2

Did you find new information about the issue by using augmented reality?		
Yes	51	83.6%
No	10	16.4%

Table 4. Answers to question 3

Did the activity help you repeat the lesson of biology?		
Yes	58	95.1%
No	3	4.9%

Table 5. Answers to question 4

Did the apps help you understand the anatomy?		
Yes	58	95.1%
No	3	4.9%

The last task for the students was to identify endocrine glands in individual anatomical systems in the application “Anatomy 4D”. The application offered English anatomical names. Some students accepted it as a challenge and began to search the terms on the internet (Table 1, category no. 2, subcategory no. 2). Based on the video-recordings and observations, it was quite clear that the students collaborated to solve their tasks; they explained some terms and relations to each other and they performed activities without any major interventions from the teacher (Table 1, category no. 2, subcategory no. 1 and no. 3). For some students, this application caused some reluctance to look at the systems. They expressed it with statements like “That's weird”, “That's disgusting” or “That's awful” (Table 1, category no. 3, subcategory no. 3). 6.6 % of students did not like this mobile technology (Table 6). This is also reflected in subcategory no. 3 (Table 1, category no. 1 and no. 3). However, the work with the augmented reality was interesting for 93.4 % of the students and 98.4 % of students admitted that biology lessons would be more fun if augmented reality was used (Table 6 and 7).

Table 6. Answers to question 5

Did you like the augmented reality activities during the biology lesson?		
It was interesting	57	93.4%
It was not interesting	4	6.6%

Table 7. Answers to question 6

Do you think a biology lesson would be more fun with the use of augmented reality?		
Yes	60	98.4%
No	1	1.6%

Our results confirm the use of mobile technologies during study is a very actual topic. Up to 83.6 % of students use a smartphone or tablet to learn (Table 8). Students use a smartphone or tablet to search for information (91.8 %), to read online study materials (59 %), and to view e-learning study materials (41 %) (Table 9). 62.3 % of students think the mobile technologies are useful in teaching biology (Table 10), and 85.3 % of students think it is effective if students are more likely to use smartphones and tablets to teach biology (Table 11).

Table 8. Answers to question 7

Do you use a smartphone/tablet to learn?		
Yes	51	83.6%
No	10	16.4%

Table 9. Answers to question 8

How do you use a smartphone/tablet while you study?		
I'm looking for information	56	91.8%
I read online study materials	36	59.0%
I look at e-learning study materials	25	41.0%
I do not use it to learn	5	8.2%

Table 10. Answers to question 9

Do you think the mobile technologies are useful in teaching biology?		
It is very useful	38	62.3%
It is only a little interesting	20	32.8%
I cannot judge	3	4.9%

Table 11. Answers to question 10

Would it be more effective if students used smartphones/tablets in biology?		
Definitely yes	24	39.4%
Probably yes	28	45.9%
Probably no	6	9.8%
I do not know	3	4.9%

In terms of the categories we established, the category of the manipulation activities was the most extensive (Table 1, category no. 3, subcategory no. 1 and no. 2). The students immensely enjoyed the manipulation activities. They improved their manipulation ability by mobile technology of visualisation and in their communication, collaboration prevailed. It was again something new to them.

4. Discussion

The simplicity and mobility of mobile devices allows for more effective learning and retainment of knowledge (Balog, Pribeanu, 2010; Kaufmann et al., 2000). Education can be viewed as the externally facilitated development of knowledge. This external influence can take many forms (a teacher, textbook, computer program). The role of visualisation in the educational context is to facilitate the learning of knowledge (Segenchuk, 1997). Using AR features, like one of the visualisation methods, students should facilitate the learning of complex subjects and should not have the problem of remembering information for a longer period of time (Azuma et al., 2011). Our findings confirm that most of the students recognised that mobile technology helped them to repeat the lesson and helped them understand human anatomy. However, it is important to connect visualisation with the knowledge that the student already controls (Segenchuk, 1997). Therefore, we used the AR method in the lesson, repeating the curriculum in the form of neurohumoral regulation of growth and development. It appears that the use of AR technology in the education of complex subjects is effective. Students are moving from instructed learning to a self-centred learning method. Although technological intervention has been present in education for a long time, AR technology has not been fully accepted (Azuma et al., 2011). Many previous studies even state that AR technology has been ignored in education, particularly in university education (Chu et al., 2010; Tsai et al., 2012). According to Billinghurst (2002), this technology is still underutilised, because there is still a shortage of qualified teachers who are able to teach complex subjects using augmented reality (Dunser et al., 2012). Another issue in introducing AR technologies into the teaching process is the lack of material and technical provision of the university. During our research, we experienced Wi-Fi internet connection problems, which sometimes made it difficult to load the AR applications, reducing the effectiveness of using tablets and AR applications in biology. In general, researchers in educational technology are in agreement that more motivation studies of AR as a learning method are needed (Chen et al., 2017; Lee et al., 2012; Margetis et al., 2012; Rogers, 2012). The use of AR technology in education could help students improve their knowledge of the subject, increase their motivation to learn, and ultimately improve their own involvement in the learning process. The AR application of anatomy (like "The Brain iExplore" and "Anatomy 4D") will assist them in learning human anatomy using enhanced materials that stimulate their interest. Based on the study results, we encourage higher education institutions to accept AR application because visual demonstration and visualisation in the educational process brings a faster understanding of the subject in the curriculum and increases the interest in learning complex subjects.

5. Conclusion

Previous study was focused on analysing the use of mobile technology, manipulation activities, and visualisation in the science and engineering education of biology, based on constructivist and constructionist concepts. Using a combined method of evaluating results (qualitative pedagogical research relied on a description of teacher observation and video and quantitative research consisted of questionnaires on student interest in this type of teaching), we evaluated the efficacy of tablet use in the learning process and the benefits of visualisation in teaching. We believe that by using this method, students' understanding was deeper, their motivation was greater, and, last but not least, their creativity was strongly supported. In conclusion, students were motivated by the new method, they cooperated very well, and learning was constructive. They gained new knowledge and collaborated. Students applied corresponding cognitive tools, such as thinking and speech, in connection with the cognitive prostheses available in their surroundings. Their minds were thus formed in a different way, which means that digital technology and visualisation delimit and structure cognitive schemes in a way that would be unfamiliar to students of previous decades.

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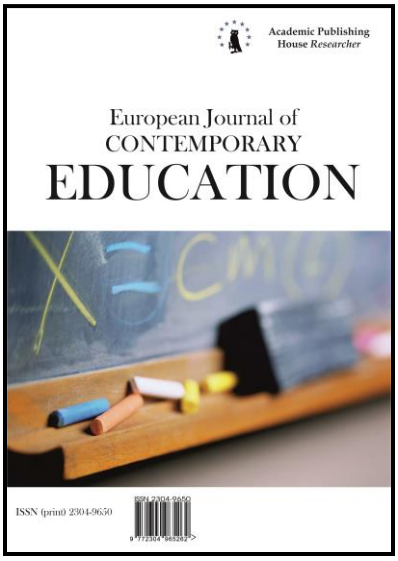

Visual Literacy and Visualization in Instructional Design and Technology for Learning Environments

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Abstract

The purpose of this study is to discuss the effects of visuals, visual literacy, visualization and multimedia design strategies using instructional design (ID) models for developing projects in education and science education, as well as engineering education. This study discusses and presents ways to evaluate visuals, visualization, and virtual technologies (as VR/AR and 2D-3D) in science education and engineering education based on research and foundations of visual learning, visual thinking, and visual communication. This study is a literature review work concerning visual effects, visual literacy, learner perceptions and technological variables for designing multimedia instruction and learning projects in visualization. In addition, this paper discusses similarities and constraints in using ID models for designing multimedia projects from the perspective of the use of visuals and ID models for developing visual materials in education. These procedures include the perceptual and theoretical foundations of visual learning, cognitive factors of visual images, visual design and program of systematic evaluation steps, as well as multimedia projects design and development materials with ID models, such as the decide, design, develop, and evaluate (DDD-E) model (Ivers, Barron, 2010) and a human information processing model (Mayer, 2001). With these models, all considerations for visual typology will be indicated in the implementation of visuals, learning design, visualization using virtual reality technologies and evaluation of visuals in multimedia development. Concluding the paper, meaningful connections between visuals and technological variables for developing multimedia project design will be considered. Indicators for learners and designers and teachers will be shown in learning imagery for visualization activity and educational technology. This will be followed by a discussion of the use of visuals and evaluation of visual materials based on the program of systematic evaluation developed by Dwyer (1972, 1978, 1987, 1994).

Keywords: visual literacy, visualization, instructional design and technology, learning.

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1. Introduction

In line with the progress of research in science, education, instructional technology and learning design, the teaching and learning process needs to involve different aspects, such as the conceptual, verbal, virtual or spatial levels. They can be characterized in lessons as problem solving, learning from images and also presented as relationships on macroscopic, microscopic and symbolic levels, especially in the educational and instructional development process using instructional design (ID) models. These levels have been clearly used in science research work and linked to ID models with visualization, which is part of visual literacy and visual thinking (Rundgren, Yao, 2014; Gilberd, 2008; Ipek, 2003, 2010, 2011; Ipek, Ziadinov, 2017; Moore, Dwyer, 1994).

2. Discussion

Visual literacy consists of visual learning, visual thinking, and visual communication (Seels, 1994). The philosophy of visual literacy has a long history of defining visuals, visual designs and information processing as communication in learning forming pictures for how to think in designing visuals and completing parts of figures, such as puzzles. It means how to understand concepts, images and screens while visually thinking in science courses to learn from images. This visualization, is not only part of all scientific fields, such as construction, engineering, architecture, instructional design, and educational technology, but also pertains to geography and chemistry. Visual attributes have been used since the second half of the 19th century due to technological invention associated with the use of photographs and other visuals. In connection with the visualization of culture was a gradually developing visual literacy. The first definition of visual literacy used in 1969 by John Debes, who was one of the pioneers of visual literacy, conducting research in image and visual perceptions. Others who have influenced thinking about the concept of visual literacy include Clarence Williams, Colin Murray Turbanye, Rudolf Arnheim, and Robert McKim (Hortin, 1994). The Eastman Kodak Company also played an important role. Researchers investigating the left and right hemispheres of the brain and perception theory, as well as artists and educators have made important contributions to the visual literacy field. Visual literacy is one of the first areas in literacies, some of which have appeared with the new technologies and developments in learning design with multimedia in science education and engineering education, as well as in the field of instructional design, educational technology, and other areas.

The study of visuals and multimedia design strategies is a broad and complex mixture of many disciplines, perceptions, interests and material design functions, as well as user-learner interface design considerations and learning from pictures. Instructional designers, scholars in visual design and material development activities and experts in distance learning are interested in using visual variables and functions to develop screens using visuals and multimedia development strategies. They also use visual literacy concepts extensively for learning and teaching subjects in education and engineering education. Visual literacy is the main field of understanding all the variables contained in visual design and learning design for teachers and students in order to improve development of instructional elements for visualization in learning (Dwyer, 1978; Moore, Dwyer, 1994). Visual communication; for example, showing graphs and simulations, as well as using concept mapping in the classroom, is one of the important and effective strategies in promoting student learning and assessing student understanding in science, engineering and art education.

The purpose of this study is to discuss the effects of visuals, visual literacy, visualization and multimedia design strategies with ID models to develop projects in education and science, as well as engineering education. The paper also discusses and presents how to evaluate visuals based on research and the foundations of visual learning, visual thinking, and visual communication as components of visual literacy. To improve the design visuals, learners should follow the new technologies and acquire better design strategies, performances, and teaching theories within definition of visual literacy and its concepts for visualization of imagery.

The Definitions of Visual Literacy and Instructional Design and Technology (IDT)

Disciplines, such as art, education, linguistics, philosophy, and psychology have all contributed to human knowledge and understanding of visual literacy, which consists of visual learning, visual thinking, and visual communication. Theoretical foundations and theory of visual literacy also emanate from these disciplines (Barley, 1971: Debes, 1968a, 1968b; 1972). Visual literacy is based on the four areas of linguistics, art, psychology, and philosophy (Hortin, 1994). From this perspective, visual literacy and perception have a role in the communication and learning process that also involves the instructional design activity and educational technology movement (Seels, 1989: İpek, 2001a, 2001b). In addition, Braden and Hortin (1982) suggested a new definition that "visual literacy is the ability to understand and use images, including the ability to think, learn and express oneself in terms of images" (p. 41).

3. The relationships between visual literacy concepts

As presented above by Moore & Dwyer (1994) and Seels (1994), visual literacy consists of visual thinking, visual learning, and visual communication to provide strategies for learning from pictures and images in the education process. Since the beginning of its development in the 1970s, the concept of visual literacy was defined as instructional and learned ability to interpret visual messages clearly and create messages in learning. In addition to this approach, another definition was presented by Curtiss (1987) in that visual literacy has a further dimension, which adds a communication process to understand visual statement in terms of learning and teaching. Thus, the visual literacy cube shown in Figure 1 was developed to present the relationship between constructs, including visual communication, visual thinking, and visual learning. Figure 2 shows the continuum of those visual literacy components.

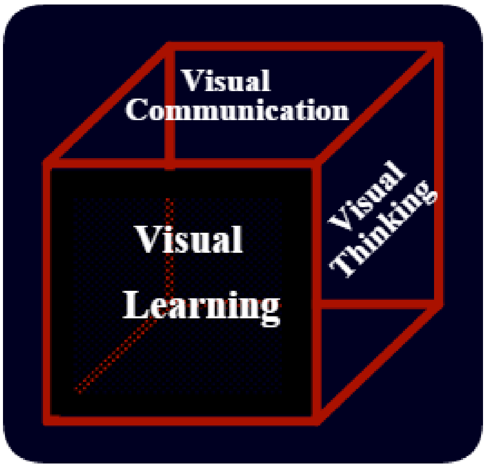

Fig. 1. The Visual Literacy Cube (adapted from Seels, 1994)

Figure 2 shows those visual literacy components from a geometric perspective, a continuous line known as a continuum.

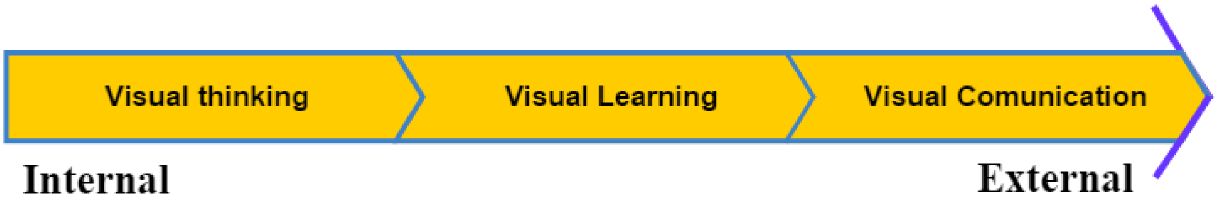

Fig. 2. Visual Literacy Continuum (adapted from Seels, 1994)

The terms used in Figures 1 and 2 are explained below.

Visual Thinking: This is the internal reaction that manipulates mental imagery and a more sensory and emotional combination in the learning process. Thus, it includes the unity of perception and conception, which indicates an ability to see visual shapes as images, including pictures, signs, and symbols (Arnheim, 1969). Visual thinking is connected with the organization of mental images around the visual components which include shapes, lines, color, and textures (Wileman, 1993).

On the other hand, McKim (1980) defines visual thinking as the interaction of seeing, drawing, and imaging as shown in Figure 3. Visual thinking strategies include transform, manipulate, concretize, timescan, and abstract functions. These aspects are very important to keep in mind when developing visuals for multimedia projects design and multimedia learning with user interface design strategies by means of instructional design models. Visual thinking refers to visualization through images, which are also mental pictures of sensory experiences, perceptions or different conceptions in learning environments for science and engineering (Seels, 1994). At this point, the sources of imagery are an important part of the visual thinking process when learning from abstract contents and invisible forms of lessons. Visual thinking contains all human activity, from the abstract and theoretical to the down to earth and everyday aspects for people. Examples of those who adopt the process of thinking in visual images can be seen in the daily lives and careers of surgeons, astronomer, chemists, mathematicians, engineers, business people, architects, and carpenters. This process is carried out by three kinds of visual imagery, drawing, seeing and imaging, as shown in Figure 3.

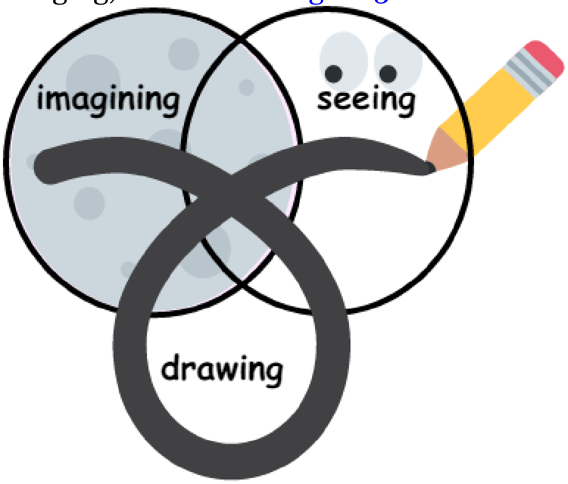

Fig. 3. Components of Visual Thinking (taken from McKim, 1980)

The interactions between the three aspects of visual thinking continue until the contents are visualized and the problem is solved. Thus, visual thinkers utilize seeing, imagining, and drawing in a fluid and dynamic way, and moving from one image to another (McKim, 1980).

Visual Learning: This is located in the most complex theoretical environment because it refers to learning both from the visuals and the research concerning the design of visuals and visual learning materials for instruction (Seels, 1994), as well as science and engineering education in educational technology. Visual learning, referring to learning from pictures and media, was first used as a title of television workshop in New York, State Board of Education in 1976. Visual learning as meaning research was first used by Dwyer (1972, 1978). In addition, Fleming and Levie (1993) presented message design principles for the designing instructional visuals based on behavioral approaches for designers and educators.

Visual Communication: This component should be added to develop the multimedia design process with human information processing and multimedia development model as indicated by Mayer's Model (2001). Wileman (1993) defines visual communication as "the attempt by human beings to use pictorial and graphic symbols to express ideas and to teach people in and out of school setting" (p. 13). According to Seels (1994), visual communication is the use of visual symbols to express ideas and convey meaning. Generally, communication can be defined as an interactive or transactional process in the learning and teaching visually in educational technology.

Thus, it is very important to develop visuals for the design of multimedia projects and multimedia learning with user interface design strategies by means of ID models. Thus, as indicated by Mayer's Model (2001), visual and instructional communication should be incorporated into the multimedia design process using a human information processing and multimedia development model.

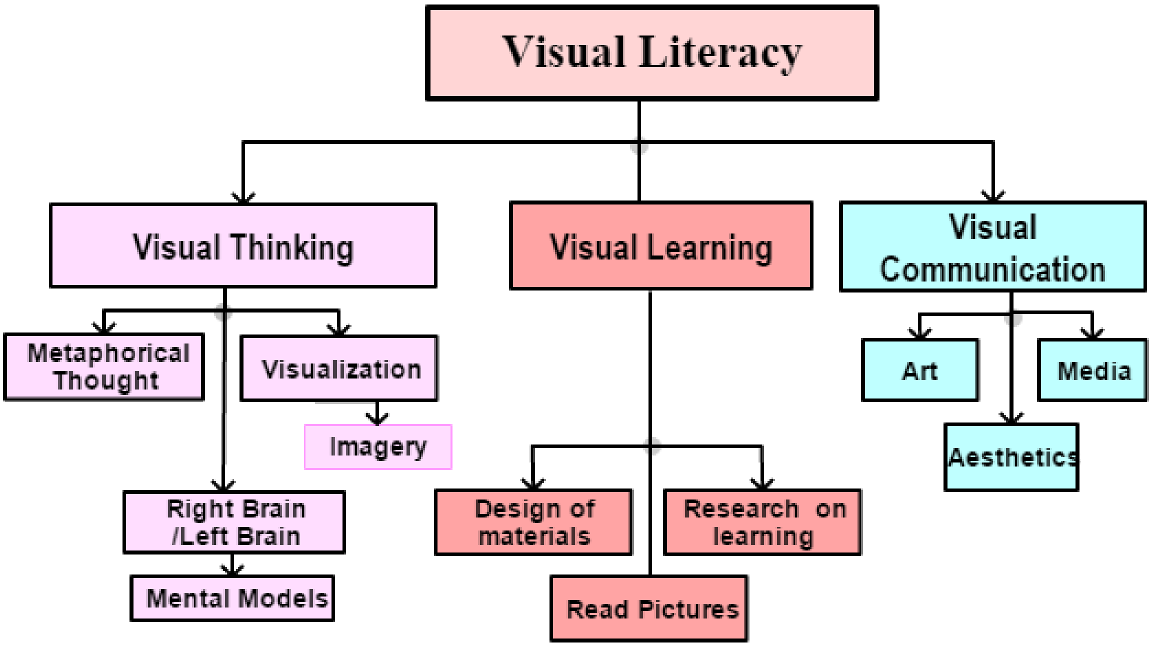

Fig. 4. Relationship of Areas of Study in Visual Literacy (Seels, 1994; taken from Moore, Dwyer, 1994)

Types of Visuals

Visuals as important instructional elements and variables in multimedia learning, visualization in engineering education, and science education can be categorized by size as medium and large. They are also defined based on their purpose, roles and content. Pettersson (1989) refers to symbols and pictures as visual languages and presents three kind of language for creating visuals and information as messages in learning and teaching: verbal, audial, and visual. According to Pettersson (1989), there are new forms in visual literacy, which are audio-verbal, verbo-visual, oral-visual, and texi-visual. They refer to combination of verbal language and visual language for designing learning in the educational process for ID, technology and information design.

On the other hand, there are other definitions of visuals. The characteristics of visuals can be assigned using these three forms (Dwyer, 1994). Static visuals include picture and other printed or projected images. There are also different visuals, such as dynamic, written (static) and spoken (static) verbal elements. Dynamic visuals include animation, video, and film. Personal visuals can be defined as a subset of dynamic visuals, including sign language, body language, and gestures. Written (static) verbal elements refer to words, and all forms of text. As a last type of visuals, spoken (dynamic) verbal elements include the spoken language in audible and visible forms of text (Braden, 1994). In addition to Braden's work, Wileman (1993) created a typology of verbal and visual image relationship. This approach contains seven steps presenting his typology for visual design. Visual designers and software developers should be aware of the types of visuals and their effectiveness on multimedia, learning and e-learning designs to use in the visualization of subjects in science or engineering education.

The definitions of visualization, representation and model in research

Visual communication is essential to promoting ideas in lessons, and visualization has been widely used in science education and learning, instructional and art design to represent scientific and technological concepts over many years to visualize visuals as sensemaking (Cook, 2006; Gilbert, 2008). There are several divisions for visual communication performance, namely art, instructional materials, and audiovisuals Visual communication will be possible using art, instructional materials, and aesthetics for visualization of contents to make invisible contents visible. Visual communication design research includes art history, design fundamentals and history, philosophy, film critique, photography, human behavior, and any other subjects related to human visual perception and communication. There are also other design areas; e.g., graphics, user experience and user interface that focus on the visual aspects of the design, as well as the user flow behind the design activities for IDT as an educational technology field.

Today, there are different definitions of visualization, but they mainly consist of the external representation (ER), internal representation (IR), and visualizing process (VP) of cognitive and brain activities (Rundgren, Yao, 2014). Visualization also means sensemaking its framework includes several steps in the learning or teaching process, such as providing an information environment, creating cues within community, using the cues and collaboration for creating patterns, building mental models, which create an action plan for the workplace, and building new information, and finally the new information starts as the visualization cycle in learning process. During this process, human cognitive architecture includes a working memory of limited capacity and duration with visual and auditory channels, and effective long-term memory. At this time, cognitive load theory uses this combination of information and cognitive structures to guide instructional design systems and educational technology. For this, as indicated in the visualization framework given above, visualization and instructional design require an information structure and also include human cognitive architecture incorporating short-term memory, working memory, long-term memory, schemas, automation, and some instructional effects, such as split-attention, modality, redundancy, interactivity, and imagination (Sweller, 2018).

Visualization in learning is not the same as visualization in instruction (Winn, 1980, 1982). To understand why this is so, it is important to describe the relationship between learning and instruction to control the learning and teaching process for working in education. As indicated by Shuell (1980), instruction indicates the control of learning processes. This means that instruction uses processes that are external to the learner, while learning uses internal processes which are psychological variables dealing with perceiving information, assimilations, perceptions, storage and interpretations. In addition, a further point should be considered in that learners have mental skills to learn from images for visual thinking in visualization. This imagery can be used in the same situations, shape or form by learners. Imagery is also a basic part of cognitive process and of mental skills. Instruction involves the control of cognitive process and uses learning strategies, such as applying mental skills. In this process, instructional strategies in the instructional design field include orienting tasks and student capabilities. Student capabilities are similar to mental skills as well.

Tufte (1983) views visualization as ER with a systematic demonstration of information in the form of pictures, diagrams, tables, and the like. By the same token, in the later years, colleagues in different research groups have defined visualization as any type of physical representation designed to make an abstract concept visible or understandable for learning objects (Rapp, Kurby, 2008; Uttal, O' Doherty, 2008). Visual representations (VRs) are essential for communicating ideas and concepts in science education, engineering and architecture, but it is not always beneficial for designers and learners in the educational process. Basically, VR deals with science concepts, such as graphics, invisible phenomena, and ID principles concerning the learner's cognitive structures for learners and educators. These graphics are often used to present multiple relationships and learning strategies in the design of instructional materials; e.g., visual and verbal information. In this process, VR in science and engineering considers the way of creating design strategies, making a decision point, and future interpretations for learners (Cook, 2006). As a result, prior knowledge, cognitive load theory, and ID considerations, such as multiple representations, animations, dual-mode effect, instructional guidance, attention, and modality are very important stages in solving problems in visualization and learning design in the science and engineering fields.

Visual Perception and Human Information Processing

A well-known research study was conducted by Dale (1969) in relation to learning with visuals effects. The study included all the processes for experiencing learning through visual literacy and visualization (Figure 5). There is a relationship between this approach and Mayer's information processing model, which starts with the two dimensions of seeing and hearing (Mayer, 2001). Visual perception, visual information processing, and the subsequent creation of adequate concepts for students are essential components of science education. Visualizations are associated with cognitive performance and mental skills. Visualization allows the application of scientific concepts of science education and engineering within a new design context.

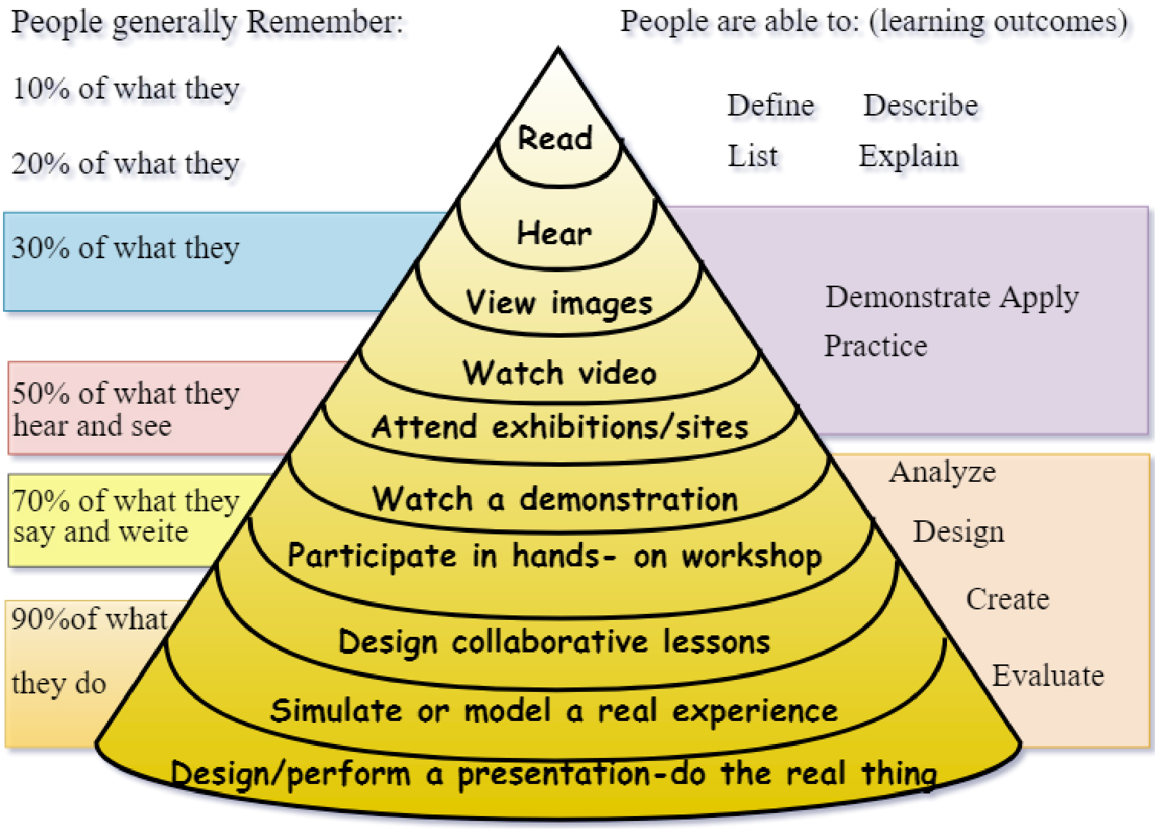

Fig. 5. Dale's Cone of Experience (adapted from Dale, 1969)

Mayer's model, learning with technology and integrated e-learning

Mayer (2001) shows human information processing process in the four parts of multimedia presentation via words and pictures, sensory memory which contains hearing and seeing, working memory, and long-term memory. The multimedia design process is shown in Figure 6.

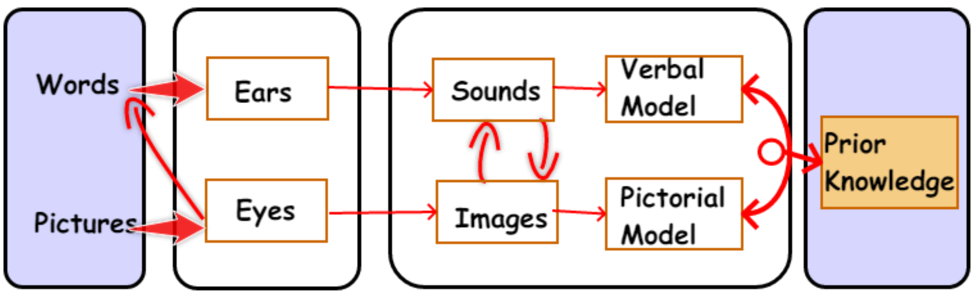

Fig. 6. A Multimedia Model (Mayer, 2001)

On the other hand, multimedia design projects should be developed based on ID models. Thus, many ID models have been developed to meet technological developments and their needs. For instance, distance education as a new area uses e-learning technologies to develop e-learning courses using visuals and multimedia tools. For this purpose, an integrated e-learning model was developed to apply ID rules to e-learning environments (İpek et al., 2008). The approach is given in Figure 7.

With the design considerations in multimedia project design in multimedia instruction, rapid ID models, and rapid e-learning design strategies use effective visuals for the instructional process, such as text, printed projects, images, combination of text and sound, and video.

The characteristics of visuals have been effectively used to develop integrated e-learning process and user-interface design process with e-learning tools and technologies. Thus, developers and designers complete all technological and instructional principles to develop high quality visuals used lessons and software packages. They also create instructional materials to be used by whiteboards and computers in schools, industry and training. At this time, the use of visuals, user-interface design rules, and e-learning design principles can be integrated to develop courseware and e-learning materials through ID models and theories (İpek, Sözcü, 2014; Sözcü, İpek, 2013, 2014). For this reason, all design process should include instructional, pedagogical and technological approaches in e-learning design, which can be defined as integrated e-learning design model (İpek, et al., 2008; Jochems et al., 2005; Sözcü, İpek, 2014).

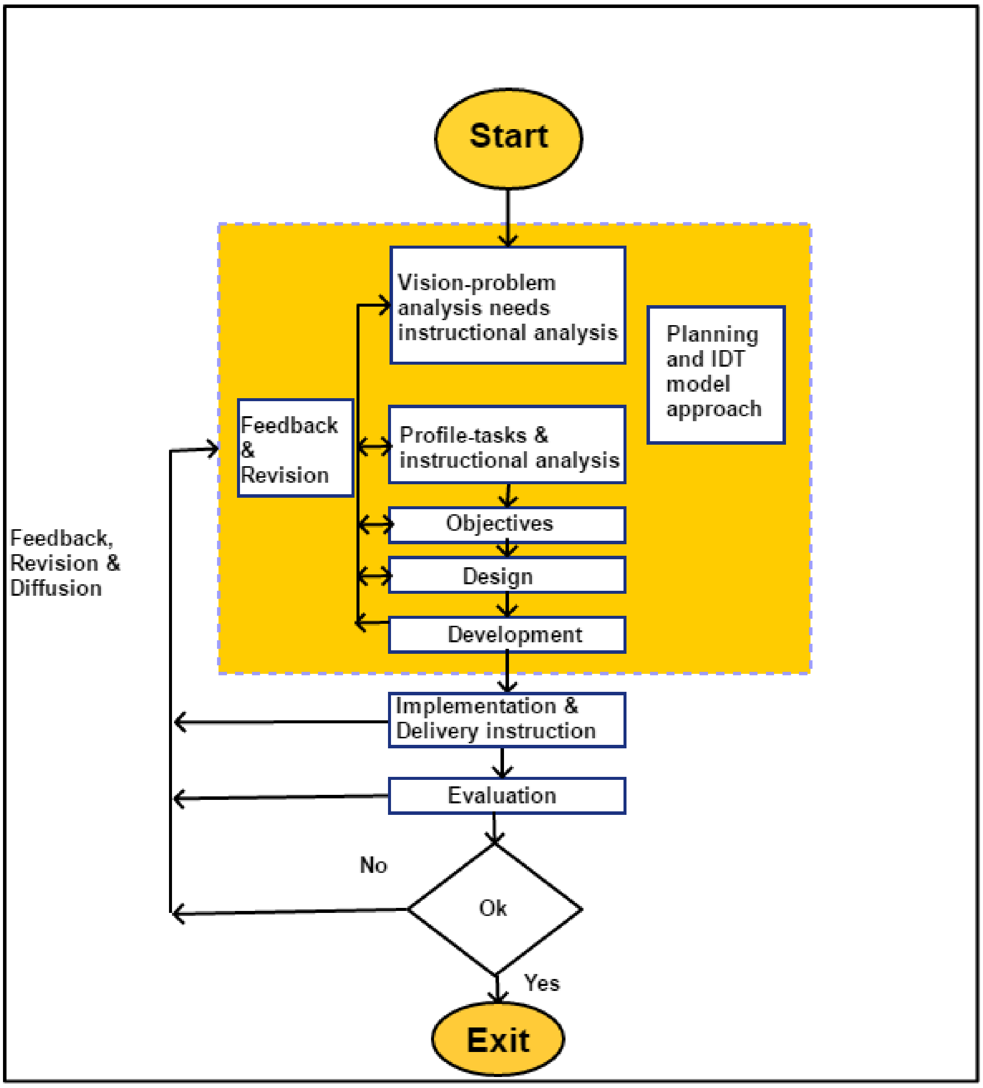

Fig. 7. Instructional Design Model for Integrated E-Learning
(taken from İpek et al., 2008; Jochems et al., 2005)

Types of visualization techniques and learning from images in education

There are several types of visualization techniques, including data, interactive, dynamic, strategy, information, concept, metaphor and compound visualization. Data visualization is a general term that describes any effort to help people understand the significance of data by placing it in a visual context. Patterns, trends and correlations that might go undetected in text-based data can be exposed and more easily recognized with data visualization software. In contrast, virtual technologies trends in education capture people's attention. Virtualor augmented reality have been applied in many sectors such as industry, medicine, education, video games or business. The media presented 2016 as the year in which virtual reality would be available for electronic learning environments, such as smartphones with different learning styles and teaching processes (Celleran-Jones, 2016; Gutierrez et al., 2015; Gutierrez, Mora et al., 2017; Sag, 2016). Thus, educational organizations can benefit from better accessibility for future performance and learning in educational technology and ID. There is a reality-virtuality (RV) continuum, as well as visual literacy. There are various categories of virtual reality technology which depends on the different degree of immersion in the visualization. For example, cabin simulators utilize a projected reality on a wide screen, augmented reality devices objects in real environments, telepresence can be used to operate in real but different locations, desktop virtual reality offers a regular display or interaction with virtual world, and visually coupled systems are employed for military aviation purposes which include sensors that track the user's eye movements following target object (Gutierrez, et al., 2015; Gutierrez, et al., 2017).

Visualization and Instructional Systems Design-Using ID Models

In the learning and teaching process using images, multimedia technologies have great potential to empower the higher-order thinking skills of learners. There are two important aspects of multimedia. First, incorporating hypermedia to enable knowledge construction by learners and designers, and second, using visualization and virtual communities to create artificial worlds (Dede, 1992). Multimedia products present the delivery of instruction, provide modeling thinking strategies and knowledge structure, building visual materials intellectually, and evaluating instruction and visuals using criteria in science and engineering. In addition, hypermedia provides a representation architecture very important in completing activities in a multimedia database by using linear, non-linear structure for the learners and visual designers as part of hypertext definition with links, nodes and buttons. On the other hand, instructional applications can be gradually developed from tutorials, simulations, games and drill-practice into e-learning environments as virtual worlds and visualization in multimedia learning environments or design. At the same time, visual learning designers and educators are using different ID models to develop efficient visuals. In addition, there are ID models used in education or industry for learning and teaching visual or virtual design, known as Bloom, universal, Seels and Glasgow, Gagne & Briggs, R2D2, Mayer, 4/C ID and integrated e-learning models, and the DDD-E model for multimedia projects design (Güney, 2018; Güney, İpek, 2017; İpek, 1995a, 1995b, 2001a, 2001b; İpek et al., 2008; Ipek, Ziadinov, 2017).

There are several types of visualization, such as sensory transmitters which use ears, eyes and hands to access phenomena. Cognitive transmitters are a second form of visualization that makes intellectual information and knowledge structures visible (Dede, 1992). Hypermedia also supports two type of visualization, computer graphics and video, to develop visuals in the IDT field, and learning design in science education. Research on learning with images shows that meaningful learning depends on the learner's cognitive activity during learning rather than the learner's behavioral activity during the learning process.

The use of visualization for effective learning design and load theory

Visualization makes the invisible visible. Thus, visualization for effective learning should be based on images, infographics, and animation (Gogia, 2018). Visualization is a task or exercise of representing content through visual and verbal ways in order to increase content visibility and retention of information. It is also part of the learning design to have strategies accurately for interpreting all contents, learning points, and main ideas and highlighting the key learning aspects in lessons, as well as creating visuals with good screens.

The use of visuals for visualization in education and engineering education

In our schools, science learning often involves creating abstract representations and models of processes that we are unable to observe with the naked eye. For example, chemistry texts often use images to represent atoms and molecules, and the processes and changes in them. Learners cannot see very well what has happened or will happen there? Since these reactions occur at a very small scale and are invisible or difficult to observe, we must use visualizations and representations to help us understand what is occurring in the process and make it visible with using multimedia technologies such as virtual and augmented reality devices for spatial skills.

An important component of scientific learning is the ability to observe mentally 2-D objects into dynamic 3-D objects for many students, particularly those with learning or cognitive difficulties. Additionally, for students with cognitive or visual impairments, the critical information contained in the representations may be inaccessible if presented in a traditional textbook, such as text and static graphics. All these visualization techniques should be effectively used in learning environments to achieve learning objectives in science education as well as engineering education. Theories about learning with multimedia can be defined at different levels. At a basic level, psychological theories define memory systems and cognitive learning systems showing how people learn information with different senses, such as spatial ability and spatial visualization with three-dimensional (3D) objects from two-dimensional (2D), presentations. It also includes spatial orientation and special relations ability to visualize the effects of operations or to mentally manipulate images (Korakakis et al., 2012; Paivio, 1986). At this level, ID models, such as universal design or 4/C ID model can be used to learn technical skills in education and science education and programming in education (Güney, İpek, 2017, 2018). However, there are some limitations for learning with virtual technologies in education; e.g., students not being competent in using technologies in an instructional environment. Virtual technologies are no exception to this. The use of new technologies does not involve necessarily innovations and improvements in learning process with instructional theories and design models. For this reason, it is required to design virtual learning environments to provide instructional design approaches to achieve all learning outcomes (Fowler, 2015; Gutierrez et al., 2015; Gutierrez et al., 2017). In addition, Lin & Dwyer (2010) indicated that static and animated visualization can be effectively and efficiently used if the time-on-task is taken into consideration in ID and strategies are practiced during visualization of images.

Program of systematic evaluation (PSE) for visuals in multimedia learning and design

The evaluation of PSE can be envisioned as having progressed through three phases (Moore, Dwyer, 1994). In the first phase, basic conceptual steps for the program were developed. At this stage, types of objectives to be used were defined. Instructional subjects with concepts were constructed. To test these concepts, all necessary criterion tests were constructed and used for students' achievement, as well as drawing realistic photographs with their color. The part includes following selected contents and criteria (Dwyer, 1994). Visual designers should be aware of these considerations in visual literacy and visual design to evaluate visuals for learning in science and education with new technologies. The following phases (Phases 1 to 3) were conducted by Dwyer (in 1972, 1978, 1987) Phase 1 was defined and summarized as follows (Dwyer, 1994):

1. Visuals do not automatically improve student achievement;
2. All types of visuals are not equally effective in providing student achievement of different educational objectives;
3. Identical visual illustrations are not equally effective when used for externally-paced and self-paced instruction;
4. A specific educational objective depends on the amount of time that students are permitted to interact with visualized instruction;
5. For students in different grade levels, the same visuals are not equally effective in increasing achievement of identical instructional objectives;
6. For specific students and for specific educational objectives, the use of color in visuals appears to be important;
7. Various visualized treatments on immediate retention tests disappear on delayed retention tests;
8. Student perceptions of the value of different types of visual illustrations are not valid assessments; that is, aesthetically pleasing visuals may deceive students concerning their instructional value;
9. The realism continuum for visuals is not an effective predictor of learning efficiency for objectives;
10. Boys and girls in the same grade level (high school) learn equally well from identical types of visual illustrations when they are used to verbal instruction.

In addition to phase 1, Dwyer (1978) indicated that strategies for visual learning include many variables, including degree of realism, cueing techniques, level of educational objectives, individual differences, method of presentation, and testing format associated with the effective use of visual materials. The following list (Phase 2) provides generalizations with visual design and learning in multimedia projects;

1. The realism continuum for visual illustrations is not an effective predictor of learning for all types of educational objectives. An increase in the amount of realistic detail will not produce an increase in the amount of information;
2. The use of specific types of visual illustrations to reach easily specific types of educational objectives significantly improves student achievement and performance in instruction;
3. All types of visuals are not equally effective in student achievement when instruction is externally-paced. The type of visuals is most effective for type of information to be transmitted;
4. The use of visuals specially designed to oral instruction does not automatically improve student performance. However, there is a relationship between educational objectives and a particular instructional method to increase student achievement;
5. The use of color for specific students and objectives appears to be an important instructional variable in improving student performance;
6. Oral instruction without visualization is as effective as visualized instruction for specific types of objectives and students;
7. All types of querying technique are not equally effective in instruction in visual illustrations.

As a final evaluation phase, Phase 3, based on research findings, indicates the variables that deal with visual illustrations and visual design for multimedia instruction. They are very important instructional components of visual design, as well as multimedia learning with visuals (Dwyer, 1978). All these variables can be used for designing visuals and technical design for instructional materials in multimedia projects. Instructional, visual and software developers should be aware of the quality of user-interface design principles, and visual design fundamentals; they should also apply and use instructional design models and their strategies effectively in multimedia learning and visual illustrations (Allen, 2007, 2011). Variables in visual illustrations and program of systematic evaluation (Phase 3) are summarized below (Dwyer, 1987, 1994).

- Cognitive trace compatibility
- Color coding
- Cue summation
- Dogmatism
- Cognitive strategies
- Computer-based instruction
- Cued recall
- Elaborate/reduced step cueing
- Encoding specificity
- Field dependence/independence
- Imagery learning techniques
- Levels of self-pacing
- Mode of instruction
- Networking
- Order of testing
- Realism
- Rote learning strategies
- Visual testing
- Eye movement
- Locus of control
- Interactive/interruptive TV
- Motion
- Free recall
- Organizational chunking
- Post questions
- Programmed instruction
- Rehearsal
- Short-term/long-term retention

Evaluation of multimedia projects

Visuals and instructional elements in the multimedia project design process should be evaluated according to IDT or multimedia design models as indicated before. Visuals and visualization should be completed and evaluated via PSE concepts, research findings, and design strategies. In addition, there is a close relationship between visual design evaluations and learner-user interface design rules to develop high quality multimedia instruction, learning, and design. To evaluate multimedia projects, for instance, the DDD-E model for multimedia projects design, development and applications (Ivers, Barron, 2010), can be used effectively and efficiently to design content, images and user-interface design steps in e-learning environment and visual design.

3. Conclusion

Visuals and visual literacy concepts, including visual learning, visual thinking, and visual communications are important design variables in the instructional design process and human information processing model, which includes the seeing and hearing variables in Mayer's model. So visual and instructional designers and multimedia designers should also be aware of the design considerations for multimedia projects, lessons, software developments, visualization types for learning imagery, and user interface design principles.

To support the development of students' learning through visualization and modeling in science and education, teachers, instructional and visual designers should consider the following rules:

- Look for new technological resources in the media center and virtual reality technologies in education for learning with images and imagery for applying representation techniques in different learning environments, such as schools, industry, and military;
- Ensure that students understand that scientific visualization and modeling are more than graphical, spatial and include visual approaches in the instructional process, such as using design models and new virtual reality and visual design technologies in science and engineering education;
- Encourage students to discuss and critique some of the approaches to models in textbooks, electronic learning environments and virtual technology trends in education. Ask them why conventions in a particular book, virtual reality technology, visual design devices or website are used;
- Consider incorporating the resources listed in literature into their science and engineering curriculum to prepare a program for visual literacy concepts and visualization in learning environments, and discuss how to use instructional design models for linking visual design performances and visualization of subjects (2D or 3D) and visual perception skills for visual materials design in educational technology.

In addition, PSE should be used to evaluate visuals, multimedia designs and future visualization activities in science and engineering education.

In conclusion, educators, designers and teachers should be aware of visual design principles, visualization types, and principles of learning from pictures to develop visuals and learning environments in science and engineering education. For this, PSE contributes to ID models in the development of visuals in multimedia learning and different visual learning environments to visualize images with mental skills, cognitive ability, and virtual reality technologies in the field of IDT.

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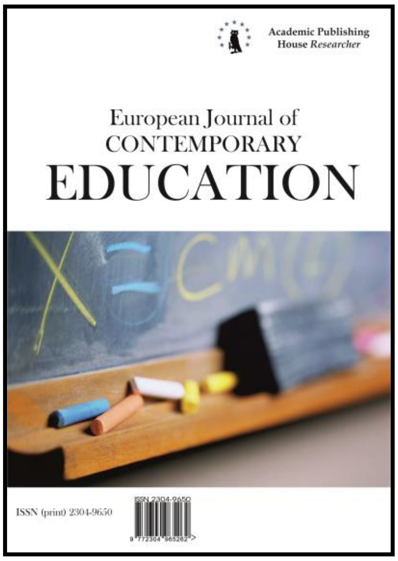

The Problems of Contemporary Education

Development of Effective Education and Training System in the Context of the Transition to International Accreditation

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Abstract

The article examines the trends in the development of higher education in Russia (in general, and in particular – higher management education). Based on the data obtained, it was concluded that the Russian system of higher education (including higher management or business education) does not have adequate competitiveness in the global market. To increase the competitiveness of Russian higher business education, it was proposed to use the Triple Crown international accreditation system (within this system, accreditation is implemented in three formats: AMBA, EQUIS and AACSB, described in this article).

Keywords: higher education, business education, business schools MBA, DBA, AMBA, EQUIS, AACSB, accreditation, Triple Crown, triple crown, competitiveness of education.

1. Introduction

We live in a unique time, when there is a change not only of the calendar cycle (one millennium ended and another began), but also a change of historical eras happens. Modern society is no longer utilitarian-consumer, and the economy is in the process of transformation from industrial to post-industrial, which naturally affects not only sociopolitical, economic and technological processes, but also processes that take place in education. At the same time, of course, in the new millennium, the quality of education, its completeness and its relevance will largely be determined by global trends in the economic and social and household sector (Dudin et al., 2015, Medvedev, 2015, Mytelka, 2018, Tapscott, 1996).

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In each nation-state, in each country, its own education system has been developed, adapted to the needs and requirements of the labor market, which determines the level and specificity of the demand for human (labor) resources (Figueiró et al., 2016; Jansen, 2017; Jones, 2016). The Russian education system went through several key stages in its development (from the formation of the scientific, and methodological basis in the first quarter of the last century to the structural transformations of the first one and a half decades of the 21st century). And each stage of the development of the Russian education system was characterized by qualitative changes that are not always and still favorably perceived by the general public.

The process of reforming the Russian educational sector is not similar to the experience of the most developed countries, and sometimes contradicts it on some issues. Transformation and modernization of higher education and science, on the one hand, are aimed at creating a new institutional space, and on the other, they are designed to change the attitude of society towards understanding the essence and purpose of the scientific and educational sphere. However, for the sake of objectivity, it is worth noting that the research and educational sphere of Russia itself is not always open to change and is practically not ready for them.

That is why the instrumental and methodological support used for the implementation of educational programs in many organizations of higher education is often not effective for the formation of professional competencies of graduates designated in federal educational standards.

2. Materials and methods

In this article, on the basis of statistical analysis of data on the global and Russian education sphere, open source content analysis and comparative analysis of scientific and journalistic works, a study has been carried out on the consistency of the hypothesis that higher education should be open to changes and largely reflect public and economic and technological trends to ensure that specialists on the labor market have broad and relevant competencies, as well as a stock of knowledge for the implementation of professional activities in modern conditions. The general methodical idea of the article is that it is impossible to increase the level of mastering of competences by graduates of higher educational institutions without changing the educational paradigm.

3. Results

The Soviet Higher School has given the world many famous scientists who, among other things, became Nobel laureates. Of course, Soviet higher education was one of the most qualitative, but at the same time the whole system of Soviet education was built in such a way as to meet the needs of military production and replenish the stock of personnel involved in the state security system, ensuring military order and working capacity of the country. In general, the entire architecture of the Soviet socio-economic system was militaristic oriented (Dudin et al., 2015, Medvedev, 2015). That is why with the beginning of market reforms in the 1990s, the entire education system was also transformed, which led to certain structural imbalances, including those related to the reduction of educational expenses (Figure 1).

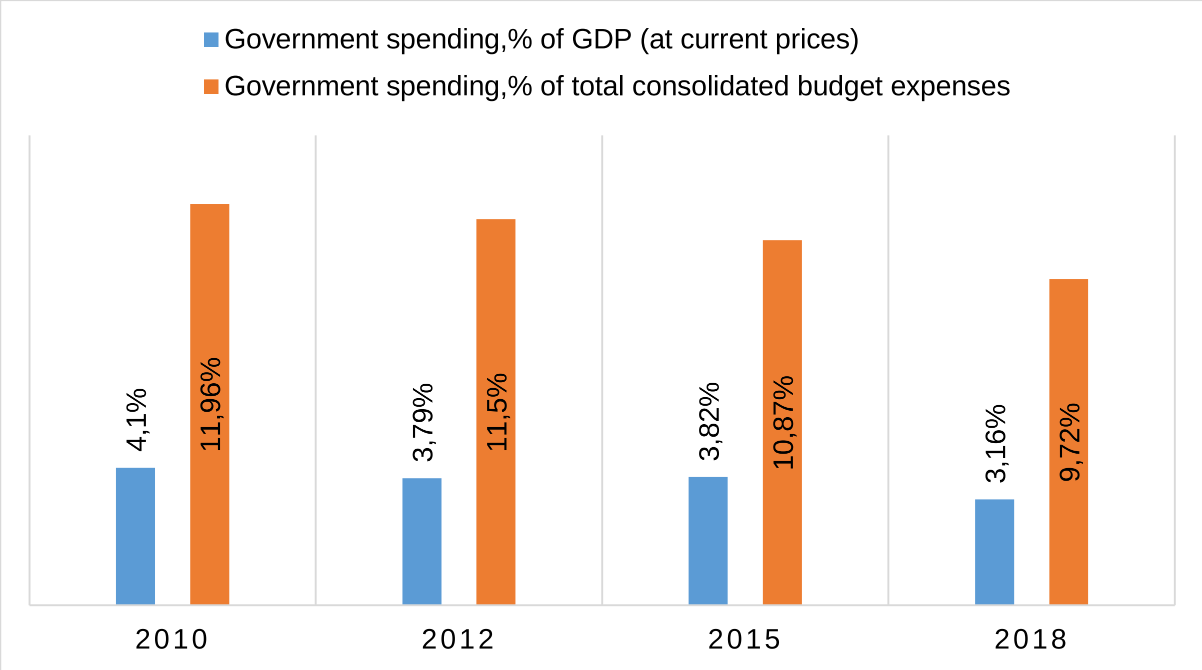

Fig. 1. Dynamics of government spending on education in Russia (Education and Literacy)

However, it should be noted that government expenditures in the field of higher education per student (by PPP at current prices) increased significantly from 2.8 thousand US dollars in 2008-2010 up to 4.7 thousand US dollars in 2017 – 2018 (Education and Literacy).

But the Russian education system (both general secondary and higher) is largely unable to cope with the implementation of the functions assigned to it. Russia as of 2018 is in 49th place in the ranking of countries in the world according to the efficiency index of national education systems developed by Pearson, and 33rd in the ranking of national education systems (Figure 2).

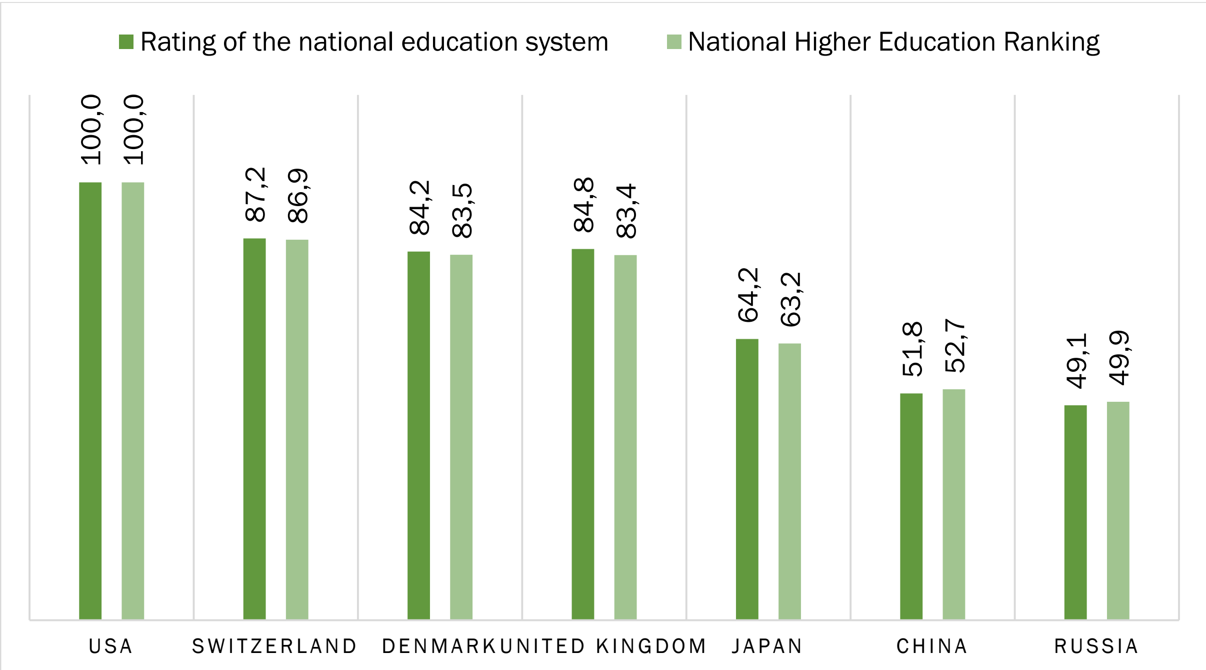

Fig. 2. Selective rating (2017) of the effectiveness of national education systems and national higher education systems (Global Index...; Ranking of Higher Education...).

It is worth looking more closely at the evaluation components of the rating; There are only four of these components, and they are structured as follows:

• resources (investment in private and public sector education, component weight 25 %);

• results (research and publications, the relevance of education to the needs of the labor market, the weight of the component is 40 %);

• communication (degree of openness of the higher education system, weight 10 %);

• environment (state policy, accessibility of education, weight 25 %)

The reasons for the low rating of the Russian higher education system are obvious: private and public sector investments in the higher education system are declining. This affects both the results and the links with other higher education systems. And this indicates that the Russian higher education system is not fully integrated into the global scientific environment. Obviously, with such a level of efficiency in the functioning of the educational sphere, the personnel shortage in the real sector can persist for quite a long time.

If we look at the world ranking of universities (QS) over the past three or five years, it can be noted that the positions of universities in China are much more advanced than those of russian universities: Peking University occupies 30 position, Fudan University, respectively, 49 position, Nanjing University occupies 122 position

Among the Russian universities of the first hundred of the leading universities in the world are Moscow State University of Lomonosov takes 90 position, the second leading university in the country, St. Petersburg State University takes only 235 place (QS Rankings). In addition, Russia has a very low influence in the global scientific environment, which does not allow for the implementation of effective and relevant research projects.

In the 21st century, the importance of higher education quality increases as the demands of the labor market in connection with the development of technology and society become more complex, while the importance of international recognition of the quality of national educational systems or individual components of these systems is growing. In the last decade, new subjects and objects, conditions and factors, programs, norms, standards, criteria for evaluating the results of the functioning and development of the world and national education systems have appeared (Jansen, 2017; Jones, 2016; Mytelka, 2018; Tapscott, 1996). Globalization, integration, standardization and internationalization are the driving force of these changes, causing the formation of various national models of higher education in search of the most effective way to build them in order to improve the quality of the education system or its individual components. This ultimately affects the pace and quality of a country's economic growth. For Russia, this issue is most relevant, since the realities in the national economy are such that without attracting new progressive managerial personnel, it will be impossible to solve the accumulated problems.

According to the portal MVA.SU in Russia today there are about 100 business schools (MBA.su). Recently, competition between them has only intensified, each business school is trying to declare that its programs are better and more internationally recognized than others, and therefore all sorts of rankings and ratings are becoming more and more popular, allowing future students and students to make a choice in favor of one or another educational organization. Business schools are evaluated on the basis of market parameters, the growth of graduates' incomes, the availability of accreditations and criteria determining international recognition.

But almost the only and most objective criterion for business schools to be international is international accreditation (Myasoedov, 2018). Accreditation is a quality assurance process in which an independent organization assesses the quality of instruction in a particular educational program or business school as a whole. When a business school is accredited, this means that it meets the list of standards confirming that students enrolled in its MBA programs receive high-quality education (Study. EU).

4. Discussion

There are many international accrediting organizations in the world, but the most prestigious and recognized are three: AMBA, EQUIS and AACSB (Figure 3).

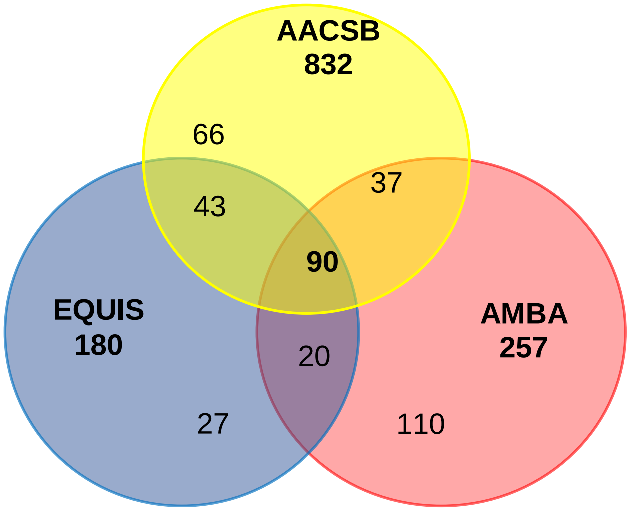

Fig. 3. Number of business schools accredited by international accrediting agencies (AMBA, EFMD Global, AACSB).

The Association of MBA (AMBA), founded in 1967 in the UK, specializes mainly in MBA programs. Today, the association has accredited over 250 business schools in 70 countries of the world (AMBA). AMBA differs from AACSB and EQUIS primarily because it does not accredit the programs of the first higher education. AMBA supports a global network of students and graduates of accredited MBA programs, as well as MBA employers. It also means that graduates and students of AMBA-accredited programs have access to a number of services and privileges, including international workshops, unique networking and access to a global knowledge base and talent.

AMBA requirements include some criteria that are not typical of generalistic institutional accreditations. For example, AMBA implies a strong interaction between the teaching staff and the group being trained, this requirement puts in front of unequal conditions full-time and distance MBA programs. AMBA accredits MBA programs older than three years, the process of obtaining accreditation takes, on average, 2 years.

The EFMD quality improvement system (EQUIS) is a European quality improvement system established by the European Foundation for Management Development in 1997. To date, 180 business schools in 44 countries around the world have been accredited [19]. Accreditation EQUIS is the most comprehensive institutional accreditation system for business and management schools. It is recognized worldwide by students, teachers, employers, corporate clients and the media, and is often the preparatory and necessary stage for getting into international rankings. EQUIS Accreditation is based on four main points (Table 1).

Table 1. The main principles of business schools accreditation in the EQUIS system (EFMD Global).

Principle	Content of the principle
Verification of quality criteria in ten directions	management system, educational programs, students, teachers, research work, internationalization, ethics, responsibility and sustainable development, corporate engagement
Broad base for evaluation	accreditation covers all areas of business school activity, including knowledge generation and contribution to the development of the business community.
Continuous improvement process	accreditation helps to make the process of continuous improvement part of the life of a business school, motivating it to continually develop at each accreditation and reaccreditation visit

Respect for diversity	EQUIS takes into account the huge diversity of national cultures and educational systems around the world. Also aware of the need to take into account the peculiarities of the local context in the process of accreditation assessment of each specific business school.

The main feature of EQUIS is the emphasis on internationalization. EQUIS assumes an international variety of both the managing board and the supervisory board of the business school being accredited. EQUIS also assumes that the school has an international development and promotion strategy and the necessary resources to implement this strategy. The process of obtaining EQUIS accreditation takes 2-3 years.

Association to Advance Collegiate Schools of Business (AACSB) is an association for the development of university business schools that unites educators, students, and business representatives to achieve a common goal — creating the next generation of outstanding leaders. AACSB is the oldest institutional accrediting organization founded in 1916 in the United States, and today has more than 1,600 member organizations and more than 800 accredited business schools worldwide (AACS). AACSB's mission is to encourage engagement, accelerate innovation, and expand influence in business education. The global organization has offices in Tampa (Florida, USA), Amsterdam (Netherlands) and Singapore. When an educational, professional, or business organization becomes a member of the AACSB Alliance, it joins the movement of improvement the quality of business education around the world. AACSB allows you to access a global network of high-quality business schools and leaders. AACSB integrates, disseminates and stimulates innovation and quality throughout the entire network of members, and across the business community.

AACSB accreditation is based on “15 standards” that cover everything that concerns a program: from strategic management and innovation to academic and professional interaction. Most of the leading business schools in the most prestigious rankings are accredited by AACSB. The process of obtaining accreditation AACSB takes from 5 to 7 years. Some of the world's best business schools, including Harvard Business School, the Wharton School and Stanford Graduate School of Business, have built global brands with the findings of only one accrediting organization, AACSB.

But most schools strive for the “Triple Crown”, i.e. obtaining all three of the above accreditations. Obtaining one accreditation is, of course, optimal for financial expenses, but the advantage of obtaining three accreditations allows the school to understand how to “improve your game”, to a new level of quality.

The value of different accreditations is that each of them focuses on various aspects of the business school and, therefore, schools that have the Triple Crown passed the toughest assessment on the market. Competition for the best students and listeners determines the accreditation market.

In addition, many international rankings do not consider business schools that are not accredited. For example, schools cannot participate in the Financial Times ’MBA ranking if they are not accredited by AACSB or EQUIS. As of January 1, 2019, out of more than 17,000 business schools (MBA.su) worldwide, 90 (about 0.5 %) are holders of the Triple Crown accreditation.

Almost 64 % of AASCB-accredited business schools are residents of the United States of America. It should also be taking into account that, for example, AMBA considers the MBA as a postgraduate degree, where students must have at least three years of work experience. Most educational organizations in the United States accept students with a bachelor's degree and little or no work experience and, therefore, do not meet the AMBA criteria. Moreover, AACSB accreditation is widely known in North America and a very small number of American institutions consider that it is necessary to obtain other international accreditations.

Only three US business schools have EQUIS accreditation: Babson College, Bentley University and Hult International Business School. Hult is also the only Triple crown accredited business school in America.

About 2/3 of business schools with Triple Crown are located in Europe. At the same time, among European countries, the leader in the number of accredited schools with a large margin is the United Kingdom (20 business schools), in second place is France (15 business schools), in third place is Germany (4 business schools). In Holland and Spain 3 business schools are accredited, in Denmark, Finland and Portugal – 2, in Austria, Belgium, Ireland, Italy, Norway, Poland, Slovenia, Sweden and Switzerland - one . The distribution of business schools with Triple Crown is presented on Figure 4.

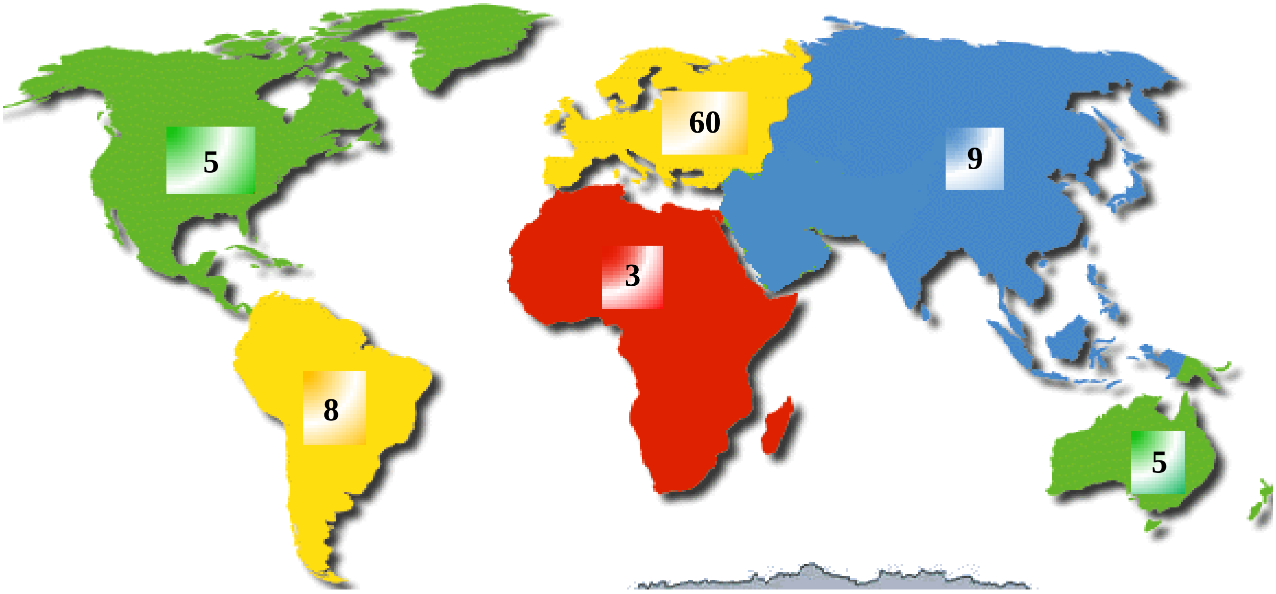

Fig. 4. Distribution of the number of business schools with "Triple Crown" by the world regions (AMBA, EFMD Global, AACSB).

Obtaining multiple accreditations entails significant financial costs, the process of obtaining accreditations of the Triple Crown will cost the business school at least $ 300,000. The size of the main contributions for the initial international accreditation is presented in Table 3.

Table 3. The cost of obtaining primary international accreditation (AMBA, EFMD Global, AACSB).

	AACSB	*AMBA*	*EQUIS*
Accreditation process	Application fee: $ 2,000 Fee for acceptance in the accreditation process $6,500 Annual accreditation fee: $29,750 – $ 41,650 *	Registration Fee: £2,000 Advance Assessment Fee: £ 5000	Application fee: €10,200 Fee for eligibility check: € 10,200
Visit of the accreditation commission	$15 000	£15 000	€17 000
Accreditation fees after accreditation**	$29750	£22 500	€17 000
TOTAL	$83 000 – $94 900	£44 500 ($56 600)	€54 400 ($62 300)
*the amount of the fee depends on the number of years spent on the accreditation (from 5 to 7 years) ** calculation for accreditation for 5 years			

The base cost of all the procedures and processes associated with obtaining an AMBA accreditation for one MBA program is £ 22,000 (AMBA), and increases in the case of evaluating programs that are implemented in other campuses or in the case of evaluating additional programs such as DBA. Also, an institution that has submitted an application for accreditation will have to pay the expenses for the arrival of members of the assessment committee (flight, accommodation and other expenses). After receiving accreditation, a new accredited member will also pay annual organizational fees.

Although all three top accrediting organizations have a common goal – to assess the quality of education, they all use different methods and focus on various aspects of management education. At the same time, all international accreditations have one common focus – faculty. Faculty are the main driver of the business school. The requirements of each international accreditation presuppose that the training organization has a policy of hiring, developing and evaluating teaching staff, as well as documents regulating research and innovation.

The most succinctly described requirements for faculty in AMBA standards. At least 75 % of faculty members should have a postgraduate education that corresponds to the profile of the subject taught. It is also assumed that most teachers have a PhD degree. In addition, faculty members must take part in one of the following activities within the business school: management research, internships and consulting. The result of participation in the activities described above is the publications in relevant journals.

The description of the requirements for teaching staff in the EQUIS accreditation standards is also interesting. Requirements are strictly prescribed only for the volume of workload that regular faculty members have. Thus, the minimum number of full-time teachers must, according to their workload, comply with 25 FTE (full-time equivalents). Also, in the case of a teacher combining teaching, administrative and research functions, the last should be a priority.

All other requirements are described in the form of listing quality criteria and a list of questions, answering which the business school describes how it organizes certain processes related to the teaching staff, and what are their features.

The most detailed requirements for faculty members in the framework of AACSB accreditation. All faculty members of the business school are divided into 5 qualification categories, depending on the field of research, practical experience, involvement in the professional environment and the mission of the business school. For the number of faculty in each of the qualification categories, AACSB establishes a certain range in percent of the total, so, for example, there should be at least 40 % of research faculty, both in the school as a whole and in each program.

At the same time, the faculty is subdivided within the framework of the AACSB into the business school by supporting and participating in the realization of the mission, the last must be at least 75 % (AACSB).

Taking into account the differences in standards of "Triple Crown" accreditation, the creation of a system combining the requirements of international accrediting organizations to the faculty and its management system will allow Russian educational organizations to reduce resources and time for international accreditations and re-accreditations significantly, as well as over the long term, it will simplify the process of entering international rankings and make them more competitive in the global market.

5. Conclusion

The materials presented in this article allow to draw the following main conclusions:

- The coming decades are the completion of the transition to a post-industrial platform, within which knowledge and human resources will be key factors ensuring the sustainable socio-economic development of countries and states. The Russian economy and the Russian higher education system are stagnant due to the lack of effectiveness of the reforms being conducted, as well as the incomplete integration of the scientific and educational community into the global environment;
- Russian higher education, including higher business education, is not competitive enough in the global market, largely due to the fact that most business schools do not have international accreditations on any of the generally accepted systems (AMBA – British, EQUIS – European, AACSB – American). European business schools seek to obtain all three accreditations, the so-called "Triple Crown" (about 2/3 of the business schools that have "Triple Crown" are located in Europe);

- The expenses of business schools for obtaining the Triple Crown accreditation is very substantial (at least 300 thousand US dollars), but these costs are repaid due to the fact that an accredited business school has the right to participate in world rankings and rankings. This in turn increases the level of competitiveness of a business school in the global market for educational services.
- for Russian business schools, obtaining international accreditations should be esteemed as an opportunity to reach a new level of development, which will encourage schools to improve the quality of management training for the real and financial sector of the economy.

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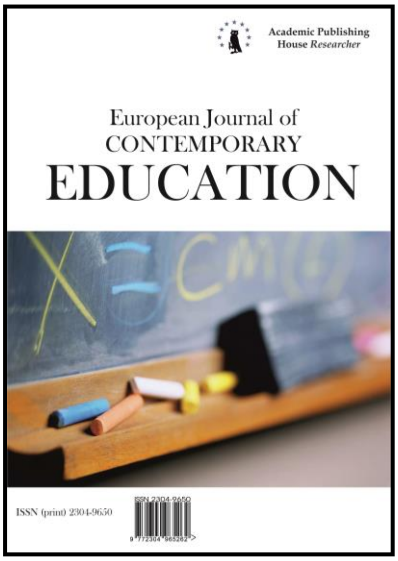

Anxiety towards Mathematics: A Case of Study in High-School Students

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Abstract

The purpose of the research was to identify the existence of anxiety towards mathematics in high-school students. A quantitative, non-experimental and descriptive study was carried out. The sample was made up by 353 high school students from the city of Rioverde S.L.P. of which 164 were men and 189 were women. A non-probabilistic sampling was used. The Auzmendi test was applied and using only the data corresponding to anxiety. The results indicate that 15.3 % of students present a low level of anxiety, 68.6 % a medium level and 16.1 % a high level, which means that a large number of students feel anguish towards this discipline.

Keywords: Mathematical anxiety, students, upper secondary education, Mexico.

1. Introduction

In Mexico, as in other countries, mathematics plays a fundamental role in any curricular plan of educational institutions because it promotes students' reasoning and analytical thinking (Ramírez, 2014). However, the studies carried out by the National Institute for the Evaluation of Education reveal that students obtain much lower levels of performance than expected, also mentioning that there is a great difference in the learning levels based on the sociocultural contexts of the students (Backhoff, 2011; Larrazolo et al., 2013).

It is important to note that mathematics is necessary in all areas of life, not because it is implicit within a curriculum of almost any degree, or because it is a competence that is acquired in the school environment and it is exclusively applied in that environment, but rather because they are part of daily life (Caballero, Blanco, 2007; Pérez et al., 2009 and PISA, 2012). In the same way PISA (Program for International Student Assessment) in 2015 considers mathematics as a key area for the development of individuals, since it is not only used in a school or professional setting, but in situations that are faced in real life.

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Regarding Mexico, high school students showed a low performance in the results of the PISA tests and in the Evaluation of the Learning (Planea). The results show that more than half of Mexican students are in the lower levels and a minimum percentage of students showed advanced mathematical reasoning and thinking (Flores, Díaz, 2013; Planea, 2015).

However, although mathematics is an indispensable component for the intellectual impulse, some students consider this discipline as a source of frustration and anxiety (Macías, Hernández, 2008). In addition, various studies carried out by pedagogues, mathematicians, psychologists and researchers find anxiety an important factor that hinders mathematical learning. In the same way (Zeidner, 1998 cited by Macías, Hernández, 2008) reports that anxiety towards math exams causes in the student that his skill and knowledge in this discipline to decrease. According to Wood (1988, cited by Pérez et al., 2009) he states that mathematical anxiety is characterized by the absence of comfort that someone could experience when they are required to perform in mathematics. In contrast, Fennema & Sherman 1976 (cited by Pérez et al., 2009), consider that mathematical anxiety consists of a series of feelings of anguish, terror, nervousness and physical symptoms that arise when solving problems related to mathematics. On the other hand, Richardson and Woolfolk, 1980; Cates and Rhymer, 2003 (cited by Cates, Rhymer, 2006) defines anxiety related to mathematics (henceforth, mathematical anxiety) as a state in which a student experiences negative reactions when he finds mathematical concepts or procedures during his mathematical evaluation. Summarizing, mathematical anxiety can be generally defined as the feelings of anxiety that some people experience when confronted with mathematical problems (Sheffield, Hunt, 2006).

The research has revealed several reasons why students experience anxiety towards this discipline and have mentioned that the mathematics course is one of the most difficult, this perception causes prejudices and predispositions to be generated and therefore, a negative attitude leading to a very high anxiety among students that hinders learning (Stubblefield, 2006, cited Kargar et al., 2010; Aliasgari et al., 2010).

According to Ashcraft and Kirk (2001), people with high math anxiety have a particular way of behaving: they take fewer math courses, get grades below average in the classes, demonstrate lower math skills and performance, and displeases the performance of mathematical tasks (Hembree, 1990; Ma 1999; Jung, Kim, 2008; Ko et al., 2011).

Wern (2016) studied how to reduce the level of anxiety in university students, for it he determined the level of anxiety, by comparing the scores of the mean and standard deviation of the Mathematics Anxiety Rating Scale (MARS). Students who had scores below one standard deviation were anxious about this discipline, meanwhile, the level of anxiety was classified as average when the scores were within a standard deviation of the average scores, while the scores that were over a standard deviation of the average scores were considered as high anxiety level, their study presents evidence that a high percentage 41.46 % reflect a high level of anxiety and 27 % show a low level of anxiety.

On the other hand, Haciomeroglu (2017) shows the relationship between anxiety and attitude, his findings revealed that higher levels of attitude towards mathematics mean lower levels of anxiety. It is believed that mathematical anxiety (MA), is closely associated with the attitude since a state of displeasure in the performance of mathematical tasks - of a large amount of the population – leads later to an anxiety that is going to have a negative and significant effect in the performance, even though the size of the effect is low. On the other hand, Delgado, Espinoza and Fonseca (2017) reveal that university students present a medium level of mathematical anxiety, and this anxiety is more present in women, and they point out that students who come from a private school have a lower level of anxiety, therefore their performance is higher, unlike students who come from public schools. In the same idea, Agüero, Gómez, Suárez, and Schmidt (2017) carried out a study on mathematical anxiety in middle school students in Costa Rica and whose results showed that women have moderately higher levels of anxiety than men.

Campbell and Stanley (1963) defines anxiety as the acquired behavioral dispositions that were the result of past experiences that make a person to see the world in a particular way. Sarason and Wine define (cited Leibfritz 1990) anxiety as a phenomenon of attention, therefore, the highly anxious individual pays more attention to environmental signals than to the task at hand. According to Speilberger 1972 (cited by Leibfritz 1990), anxiety is a process that involves cognitive, behavioral and affective components. Hence, Speilberger 1972 (cited by Leibfritz, 1990) proposes the theory of anxiety based on the attributes of the attitude that indicates that anxiety is first activated by external or internal stressors. These stimuli are cognitively evaluated whether induced internally or externally. For a well-learned or simple task, the optimal level of anxiety is quite high, however, when the individual is just learning a task or when the task is extremely complex, the optimal level of anxiety is much lower (Figure 1).

Auzmendi (1992) developed a scale to measure the attitude towards mathematics and statistics that consists of five factors: anxiety, like, utility, motivation and confidence. Like refers to the taste or enjoyment that causes the mathematical work; anxiety describes the feeling of anguish, stress, fear that the student manifests towards mathematical problems; the utility of mathematics refers to the perception of importance or value that the student gives to mathematics in everyday and professional life; confidence is related to the confidence and security that the person has when facing mathematics and motivation refers to the component that maintains, guides or moves the use and study of mathematics (Hurtado, 2011), for this study only the anxiety construct was taken.

When reviewing the previous research and the results provided by PISA and SEP -which reflect a low performance in mathematics in high school students- the following question arises: Do high school students show high levels of anxiety towards mathematics?

To answer this question, the research objective is to identify the anxiety level towards mathematics in high school students.

The results will provide useful information so that the educational authorities, as well as professors and students, can suggest strategies that allow the students to conduct themselves to a better performance besides diminishing this feeling of fear to this discipline.

2. Methodology

The method used in this research is hypothetic-deductive, in this method the proposed hypotheses are exposed after obtaining information about the object of study and will determine and guide the other observations. The general hypothesis of the present study indicates that the level of anxiety of high school students has a score greater than or equal to 16, at a level of significance of 0.05. Thus, the statistical hypothesis that governs this research at a level of significance of 0.05, is formulated as follows:

$$H_0: X \geq 15$$
$$H_1: X < 15$$

Anxiety levels could be determined using the mean and the standard deviation. When the scores were below one standard deviation of the mean scores, the level of anxiety was classified as low. The level of anxiety was classified as average if the scores were within one standard deviation of the average scores. Meanwhile, the scores that were above a standard deviation of the mean scores, the anxiety level was classified as high.

The t-test of paired samples was used to compare the averages before and after for the same group. The mean differences in the t-test were determined using the p-value that was 5 % of the level of significance (Park, 2009). However, there is no control group included in this study. It was used to determine if there were significant differences in the mean for students' general anxiety level in pre and post-test. In addition, it was used to examine if there were significant differences of the mean for pre and post-test for students with low, average and high level of anxiety, respectively.

Hence, this research is "ex post facto" – because facts and variables already occurred-, observing variables and relationships between them in their context. The variables that are intended to be observed are those that allow to show the anxiety that students feel towards mathematics during the teaching-learning process. To carry out the study, we used a sample of 353 students who were in the mathematics department, which is made up of 364 men and 189 women belonging to a private high school in Rioverde S.L.P. The type of sampling was non-probabilistic. The test designed by Auzmendi (1992) was applied. It contains 25 items that can be answered with five options, five numbers: 1. Strongly disagree 2. Disagree 3. Neutral, neither agree nor disagree 4. Agree 5. Strongly agree, they measure 5 factors named: Utility (items 1, 6, 11, 20 and 21), Anxiety (2, 7, 12, 13, 17 and 22), Trust (3, 8, 18 and 23), Like (4, 9, 14, 19 and 24) and Motivation (5, 10, 15, 20 and 25). Even though the whole questionnaire was applied, only the anxiety scale was used for this research. The Cronbach's Alpha reliability coefficient was 0.916. An analysis of a difference in means was used to identify the significant variables that allow measuring the object of study, for which the data were obtained from the statistical program SSPS 23.

3. Results and discussion

The following section shows the results of the anxiety level of the students. Figure 1 shows that 46.5 % of the students surveyed are men and 53.5 % are women, their age ranges between 15 and 18 years, 31.7 % are 15 years, 48.7 % are 16 years old, and 19 % are 17 years and only 0.6 % of students are 18 years as shown in Figure 2

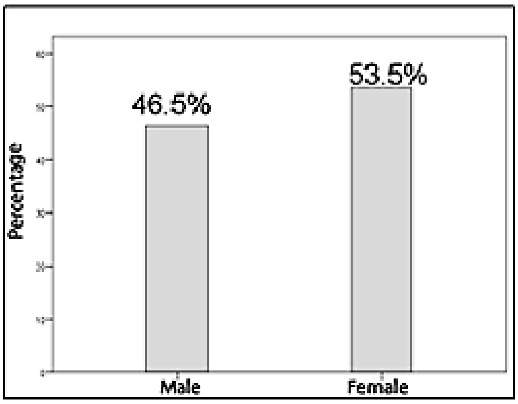

Fig. 1. Gender

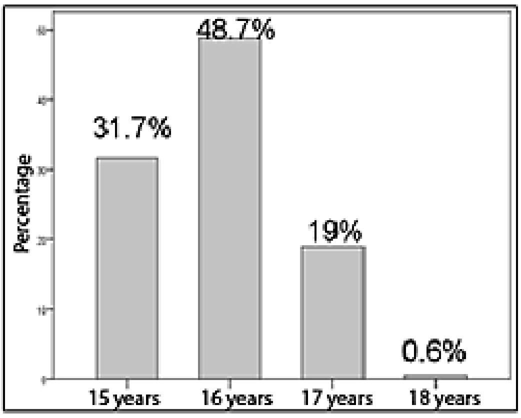

Fig. 2. Age

Regarding the grade level, Figure 3 shows 53.3 % of students belong to the second grade, while 46.7 % of students are in the fourth grade.

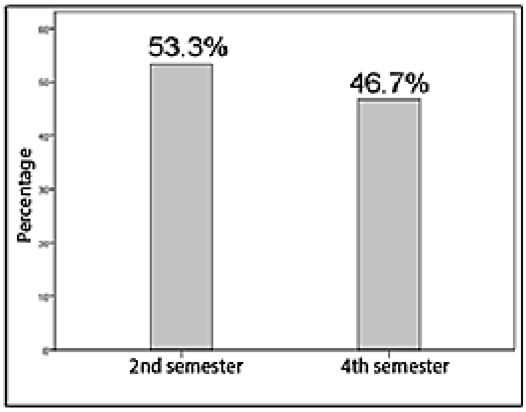

Fig. 3. Grade

Table 1 shows mean, standard deviation, and percentages of students by anxiety level.

Table 1. Mean, standard deviation, and percentages of students

Anxiety level	**Mean**	**Standard deviation**
	15.098	1.64
	Percentage	Score
Low	15.4	10-13
Medium	44.3	14-15
High	39.3	16-22
Total	100.0	
Value of t	Significance	Difference between means
0.284	0.776 ($_{352df}$)	0.00850

Source: own.

Of the sample, there are 15.4 % of students scoring between 10 and 13, a low level of anxiety, while 44.3 % are within first standard deviation (for a mean of 15.098 and a standard deviation of 1.64) scoring between 14 and 15, a medium level of anxiety. The remaining 39.3 % of the students got scores of 16 and above, meaning high level of anxiety towards mathematics.

To test the hypothesis that the anxiety level of high school students is greater than or equal to 15, the *t* test for a sample was used. As shown in Table 1, the got *t* value is 0.284 at a significance level of 0.05, which is lower than the critical value of t_{352df} (1.69), rejecting thus the null hypothesis. Consequently, it is concluded that the students of the school under study suffer of anxiety towards mathematics.

Regarding differences in anxiety levels between men and women in the sample, the Mann-Whitney U test was applied. As shown in Table 2, the resulting significance level of (0.006) is less than 5 %, so the hypothesis of equal averages should be rejected, hence concluding that the level of anxiety is significantly different between genders.

Regarding whether there is a difference in anxiety levels between grades, the Mann-Whitney U test yields a level of significance (0.675) that is greater than 5 %, as shown on Table 2. The hypothesis of equal averages should not be rejected, hence concluding that students of both grades show similar anxiety levels towards mathematics.

Table 2. Mann-Whitney U test

Variable	**Gender**	**N**	**Grade**	**N**
Anxiety Level	Male	164	First	188
	Female	189	Second	165
	Total	353	Total	353
	Mann-Whitney U	12877.00	15111.00	
	Z	-2.752	-.419	
	Asymptotic Significance (bi-serial)	.006	.675	

Source: own.

4. Conclusion

An important aspect to consider in this research is the high degree of anxiety shown by students at this level, since they are a level prior to university level, which demands more mathematical applications, this shows that it is necessary to search for alternatives to solve problems and avoid the emotional effects generated by this discipline, the use of cognitive strategies contribute to face anxiety. Worth to point out that strategies should be differentiated among gender, according to the unequal anxiety levels observed.

Lazarus and Folkman 1986 (cited by Cano et al., 1994), affirm that when the subject perceives that his resources are not sufficient to face an aversive situation, anxiety appears. Similarly, authors Mato and De la Torre (2009) mention that negative attitudes, such as anxiety, have a significant influence on academic performance, as Macías and Hernández (2008) indicate the presence of mathematical anxiety in students.

It is also important to mention that the preparation of teachers in this discipline focuses more on aspects of content, than on attitudes and feelings, for this reason it is necessary that teachers learn to diagnose and implement them through institutional designs.

5. Research limitations

This research work based on a sample of students from a single private high school that has operations in a single city in Mexico. The results were useful for the school and gave several clues about what might be happening in other private schools in the same region. However, it is necessary to repeat the same study in other public and private schools, to verify if the observed phenomenon occurs in the region and in the country, and to find differences between the regions.

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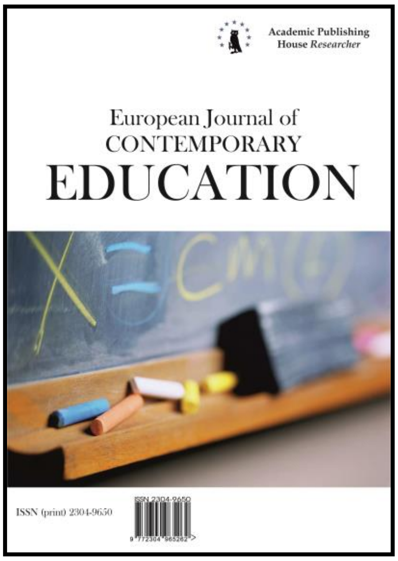

Effects of Education Programs on Dance Sport Performance in Youth Dancers

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Abstract

The aim of this study was to investigate the effects of education programs on dance performance in youth sports dancers. Fifty-four subjects (aged 9-11 years) volunteered to participate in a 12 wk education program and were randomly assigned to three groups. The experimental group one (EG-1) trained in Dance sport 2 $d.wk^{-1}$ and performed physical training (i.e. track and field athletics, games, relays, and rhythmic gymnastics) 1 $d.wk^{-1}$. Experimental group two (EG-2) trained in Dance sport 2 $d.wk^{-1}$ and performed aerobics and aerobic gymnastics exercises 1 $d.wk^{-1}$. The control group (CG) dancers developed their Dance sport-specific technical and tactical skills 3 $d.wk^{-1}$. Training occurred 3 $d.wk^{-1}$ for a total of 54 hours. The dancers' anthropometric and physical fitness characteristics, as well as Dance sport performances were measured pre and post-intervention. No significant differences were observed at baseline between the three groups, except stature in EG-2 ($p > .005$). At post-intervention, the supplemental education sessions improved Dance sport performance scores of EG-1 ($p = .004$, $\eta^2 = .673$, $P = .943$) and EG-2 ($p = .001$, $\eta^2 = .778$, $P = .996$) dance pair; no change was observed in Dance sport performance in CG-1 ($p = .622$, $\eta^2 = .032$, $P = .074$). The application of Dance sport training combined with supplemental education improves development of Dance sport performance in youth sports dancers.

Keywords: juvenile dancers, ballroom dancing, education programs, sports performance.

1. Introduction

Dance sport is becoming increasingly popular among children and adolescents, and children have started to participate competitively (Liiv et al., 2013; Kostić et al,, 2002; Shannon, 2016). Education in dance sport is oriented toward achieving mastery in physical fitness, and in developing artistic abilities to express the ideas of dance through body movements (Malkogeorgos

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et al., 2013; Torrents et al., 2011; Walaszek, Nosal, 2014). It is a physically demanding sport (Liiv et al., 2013) that involves a significant relationship between technical fitness and motor abilities, such as body balance, flexibility, speed, endurance, and strength for performing movements of the upper and lower limbs (Kostić et al., 2002). During dance sport contests, pairs of dancers are evaluated according to movement rhythm and plasticity, dancing technique, movement coherence, body posture and hand positioning, and the harmony of movements among the pair (Kostić et al., 2002; Liiv et al., 2014; Lukić et al., 2012). The synchronicity of movements, interactions between dancers, repeated sequences of movements, and contact between dancers in a pair are of great importance (Torrents et al., 2011). Sports dancers perform nonstandard dynamic movements at varying intensities (Dornowski, Zabrocka, 2008). Because these capabilities are important predictors of success in competition, it seems reasonable to improve them early in education. Therefore, finding effective education modalities for juvenile sports dancers is of particular importance.

Studies have shown the beneficial effects of physical training on the motor abilities of juvenile sports dancers (Kostić et al., 2002). Thus, positive effects of the different dance styles used in dance sport education programs for improving physical fitness have also been reported (Koutedakis, Jamurtas, 2004). Dance education programs should include exercises to develop physical fitness, but there is little scientifically valid evidence of the acute effects of these exercises on performance in sports dancers aged 9–11 years (Torrents et al., 2011). The age range of the dancers examined here was selected by considering the optimal period of motor ability development (Armstrong et al., 2011; Lloyd et al., 2014) and the age (9–11 years) at which dancers begin to compete not only in friendly tournaments, but also as juveniles in dance sport contests with awards. Therefore, here we aimed to determine whether dance sport training would have an effect on motor performance and whether physical, aerobics, and aerobic gymnastics training combined with dance sport training might have acute effects on dance sport performance scores. A 12-week-long experimental program was conducted based on published recommendations (Kostić et al., 2002; Koutedakiset al., 2007).

The aim of this study was to investigate the effects of education programs on dance performance in youth sports dancers.

2. Research methods

Participants

Fifty-four sports dancers (girls and boys, in pairs) volunteered to participate in this study. They were divided into three groups and each group used a different education program during the 12-week study. Participants had been practicing dance sport as a leisure-time physical activity for 3 years with the same teacher, following the same education program at the same dance sport club. Composition of the body, physical fitness, and dance performances were evaluated. Pairs of participants were assigned randomly to two experimental groups: E-1 (n = 18) and E-2 (n = 18), and control group C (n = 18). In group E-1, girls were aged 9.7 ± .9 years and boys 9.9 ± .8 years; in group E-2, girls were aged 9.9 ± 1.0 years and boys 9.5 ± .9 years; and in group C, girls were aged 10.1 ± .9 years and boys 9.4 ± .7 years. We applied pre- and post-intervention physical fitness tests and dance sport performances based on competition ratings. No significant differences in physical fitness, body composition, or dance sport performance were found among the groups before intervention, except for height in group E-2. The participants and their parents were informed of the potential risks and benefits prior to signing an approved informed consent document to participate in the study. The experimental protocol was approved by our Institutional Review Board.

Education programs

The dancers trained three times per week for 12 weeks: in total 54 hours. This education program was performed while preparing for the competitive dance sport season.

Subjects in group E-1 participated in dance sport training and physical training with the schedule shown in Table 1. Physical training was in the following order: running/sprinting (sprint/hurdle shuttle relay); jumping (forward squat jumping, and cross-hopping); fitness games (run, run, chicken go home; wall-to-wall; and counting jumps); rhythmic gymnastics (hoop twisting and skipping-rope jumping); and dynamic stretching exercises. Instead of the usual 15- to 20-minute warm-up used in dance sport training twice per week, specific physical training program exercises were performed.

Subjects in group E-2 participated in dance sport training and physical training (Table 1).

Physical training sessions were in the following order: aerobics and aerobic gymnastics (basic steps, kicks, jumps, strength training exercises); stretching exercises (simple stretches and stretches with elastic bands); and aerobic exercise with relaxation. Instead of the usual 15- to 20-minute warm-up used in dance sport training twice weekly, specific aerobic and aerobic gymnastics training exercises were performed.

Subjects in control group C developed their dance sport-specific technical and tactical skills but did not participate in any special physical training (Table 1). They followed the dance sport education program of three sessions per week, each lasting 90 minutes. This training was focused on the development of technical and tactical skills. These skills, which included dance step improvement (e.g., one of the standard or Latin American basic dance steps) and dance routine development (e.g., one of the standard or Latin American dance contest routines), were performed for 60–70 minutes in three training sessions per week (Table 1). Dynamic stretching exercises for the main muscle groups were executed during the warm-up period, and static stretching exercises were performed during the cool-down period.

Table 1. Characteristics of the experimental (E-1, E-2) and control (C) group education programs

Training days	Groups		
	E-1	E-2	C
Warm-up (~15 min)			
Monday Wednesday Friday	Low-intensity running exercises, dynamic stretching exercises for the main muscle groups.	Low-intensity basic step aerobics; aerobic gymnastics exercises, dynamic stretching exercises for the main muscle groups.	Dynamic stretching exercises for the main muscle groups
Dance sport training (~60 min)			
Monday Wednesday	Development of technical and tactical skills in Standard (Monday) And Latin American (Wednesday) dances, such as dance step improvement and dance routine development.		
Friday	Physical training (~60 min)	Aerobics and aerobic gymnastics training (~60 min)	Dance sport training (~60 min)
	Running/sprinting, jumping, fitness games, rhythmic gymnastics and dynamic stretching exercises.	Basic steps, kicks, jumps, strength training exercises; stretching exercises (simple and using a band); and aerobic exercises with relaxation.	Development of technical and tactical skills in Standard and Latin American dances, such as dance step improvement and dance routine development.
Cool-down (~15 min)			
After every training	Static stretching exercises were performed.		
Total intervention education time (min)*	3240	3240	3240

Variables and measures

Independent variables were used in the three different programs. As the dependent variables, we used body composition measures including height, body mass, body mass index (BMI), body fat, free fat mass, and total body water; the physical fitness variables included plate-tapping speed endurance; one-foot lengthwise balance, vertical jumps, 20 repeated rebounding jumps, flexibility sit-and-reach tests, sit-ups, and dance sport performance scores.

Body composition characteristic measurements were performed using a Martin GPM anthropometer (DKSH, Zurich, Switzerland) for height (cm), and a Tanita Body Composition Analyzer BC-418MA (Tanita Corporation, Tokyo, Japan) for body mass (kg), BMI (kg/m²), body fat (%), free fat mass (kg), and total body water (kg).

A speed endurance plate-tapping test (Fjortoft, 2010) was used to assess the speed endurance of upper limb movement. The intraclass correlation coefficient (ICC) of the plate-tapping test measurement was $r = .990$ ($p < .001$, standard error of the mean (SEM) ± .052).

A one-foot lengthwise balance test (Sheehan, Katz, 2013) was used to measure the ability of subjects to maintain body equilibrium. The ICC of this balance test was $r = .994$ ($p < .001$, SEM ± .162).

Vertical jumps (Carlock et al., 2004) were executed on a platform connected to a digital timer (Ergojump, Psion CM; MAGICA, Rome, Italy) that measured the flight time and calculated the jump height. The following four types of jumps were measured: a vertical jump with an arm swing, squat jumps with knees flexed at 90° or 135°, and 20 repeated jumps. The ICCs of the squat jump from 90° and 135° of knee flexion were $r = .808$ ($p < .02$, SEM ± .251) and $r = .973$ ($p < .001$, SEM ± .198), respectively. The ICC of the vertical jump with an arm swing was $r = .976$ ($p < .001$, SEM ± .147). The peak power (PP) was estimated in watts (W) using equation (Sayers et al., 1999):

$$\text{PP (W)} = (60.7) \times (\text{jump height, cm}) + 45.3 \times \text{BMI} - 2{,}055.$$

The ICC of the repeated jumps test was $r = .929$ ($p < .001$, SEM ± .224). To assess the level of fatigue during the 20 repeated jumps test, the fatigue index (FI) was calculated (the first jump was a preparation one) as recommended in (Naharudin, Yusof, 2013) using equation:

$$\text{FI} = \left[\frac{1^{st}\ jump\ (cm) - 20^{th}\ jump\ (cm)}{1^{st}\ jump\ (cm)} \times 100\%\right].$$

For flexibility, the sit-and-reach test (Castro-Piñero et al., 2010) was used. The ICC of this test was $r = .952$ ($p < .001$, SEM ± .153). The sit-up test (Armstrong et al., 2011) was also used. The ICC of this test was $r = .837$ ($p < .001$, SEM ± .295).

Dance sport performance in friendly tournaments held before and after the experiment was judged by three experts with national qualifications. The dancers were judged using scores of 3, 4, 5, and 6. The points given by all experts for each dance (slow waltz, quickstep, cha-cha-cha, and jive) were summed, and an arithmetic mean was calculated. The dancers performed the same routines at the beginning and end of the study and the assessment, as usual, was for girl and boy couples.

Data analyses

For raw data, we applied a Shapiro–Wilk test for assessing the normality of distribution. To compare the three different groups at the start of the program, we used one-way analysis of variance (ANOVA). To compare pre- and post-testing indices after the 12-week-long education programs (means and standard deviations) and the effects of training on each group, we used repeated measures one-way ANOVA (IBM SPSS Statistics, version 22.0; IBM Corp., Armonk, NY, USA), including initial values as variables, with η^2 for effect size and statistical power shown as P. The statistical significance level was set at $p < .05$.

3. Results

Physical fitness

Physical fitness scores during the 12-week education programs improved in the participants of intervention groups E-1 and E-2 compared with control group C scores. The results of one-way ANOVA are shown below.

The speed endurance plate-tapping test showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .397$, $P = .523$). The flexibility sit-and-reach test showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .505$, $P = .707$), girls in group E-2 ($p < .05$, $\eta^2 = .310$, $P = .386$), for boys in group E-1 ($p < .05$, $\eta^2 = .309$, $P = .384$), and boys in group E-2 ($p < .05$, $\eta^2 = .250$, $P = .302$). The one-foot lengthwise balance test showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .324$, $P = .407$), boys in group E-1 ($p < .05$, $\eta^2 = .675$, $P = .944$), and boys in group E-2 ($p < .05$, $\eta^2 = .592$, $P = .846$). The sit-up test showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .074$, $P = .109$). The squat jump at 90° of flexion showed improved scores for boys in group E-1 ($p < .05$, $\eta^2 = .665$, $P = .935$), boys in group E-2 ($p < .05$, $\eta^2 = .094$, $P = .127$), and the PP (W) result for boys in group

E-1 ($p < .05$, $\eta^2 = .705$, $P = .967$). The squat jump at 135° of flexion showed improved scores for boys in group E-1 ($p < .05$, $\eta^2 = .247$, $P = .298$), and boys in group E-2 ($p < .05$, $\eta^2 = .002$, $P = .051$); and the PP(W) result for this showed improved scores for boys in group E-1 ($p < .05$, $\eta^2 = .255$, $P = .308$) and boys in group E-2 ($p < .05$, $\eta^2 = .011$, $P = .058$). The vertical jump with an arm swing showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .260$, $P = .315$) and boys in group E-1 ($p < .05$, $\eta^2 = .625$, $P = .890$); the PP(W) values for this test showed improved scores for boys in group E-1 ($p < .05$, $\eta^2 = .644$, $P = .913$). The 20 repeated rebounding jumps test with FI (%) showed improved scores for girls in group E-1 ($p < .05$, $\eta^2 = .253$, $P = .306$), girls in group E-2 ($p < .05$, $\eta^2 = .013$, $P = .060$), boys in group E-1 ($p < .05$, $\eta^2 = .197$, $P = .236$). and boys in group E-2 ($p < .05$, $\eta^2 = .041$, $P = .081$).

The male dancers of control group C showed significant improvements in their speed endurance plate-tapping test ($p < .05$, $\eta^2 = .319$, $P = .334$). No significant changes were observed for body composition characteristics between the three groups over the 12-week study period.

Dance sport performance

Dance sport performance pre- and post-intervention scores in friendly tournaments are shown in Table 2.

Table 2. Dance sport performance scores of the three groups for the 12-week-long education program (n = 54)

Dance sport performance scores							
Group	**Pre-intervention**		**Post-intervention**		Effect size	Observed power	Statistical significance level
	M	*SD*	*M*	*SD*	η^2	*P*	*p*
E-1 *(n = 18)*	48	8.35	53	5.95	.673	.943	.004
E-2 *(n = 18)*	49	1.83	51	1.73	.778	.996	.001
C *(n = 18)*	49	.78	49	.93	.032	.074	.622

Notes: M – mean; SD – standard deviation; E-1 and E-2 – experimental groups; C – control group

4. Discussion

It has been suggested that sports dancers must be experts in the technical aspects of their sport but must also be physically fit (Koutedakis et al., 2007). The main finding of this study was that dance sport training combined with track and field exercises, games, relays, rhythmic gymnastics, aerobics, and aerobic gymnastics increased the children's dance sport performance indices. According to the literature (Armstrong et al., 2011; Hartman, Looney, 2003), in the middle period of childhood (age 9–11 years), children have great abilities to perform gross motor skills and demanding sports activities. Children in this age range are very active and willingly participate in games, relays, and other sports. The resultant enjoyment of performing various sports activities is related to the development of motor abilities (Flatters et al., 2014). Research in the dance field has corroborated the great influence of basic motoric abilities on successful dance expression (Kostić et al., 2002; Lukić et al., 2012; Aujla et al., 2014; Chua, 2014). Motor strength in dance activities plays an important role in this. Strength as a motor ability in Latin American dancers becomes apparent with the increase in bodily expression while presenting the character of the dance that is being performed. A significant relationship was found for the muscle strength of adolescent dancers in terms of Latin American and standard dance competitions (Lukić et al., 2012).

The boys in group E-1 had significantly increased scores in the 20 repeated rebounding jumps, squat jump at 90°, a vertical jump with an arm swing, the one-foot lengthwise balance test, and the speed endurance plate-tapping test after 12 weeks of education. The girls in group E-1 exhibited significantly improved flexibility in the sit-and-reach test and sit-up test indices. Thus, the education program had a positive and acute effect on the physical fitness of male dancers; however, no significant effect was found for the girls in this study. These differences in training effects might be related to the discrepancy in maturation between girls and boys, which might in turn impact on their physical and technical fitness levels (Koutedakis et al., 2007; Aujla et al., 2014;

Walker et al., 2010). Additionally, the rapidity of growth and maturity can differ for each person (Sherar et al., 2010). The physical activity levels in children and adolescents undertaking dance sport training is considered too low, and to increase training intensiveness it is recommended to use various education programs (Cain et al., 2015). If such training could support the psychological need for autonomy, competence, and related factors, it should increase the motivation for dance sport training in girls more than boys (Amado et al., 2017). These suggestions are corroborated by our results and observations on the attendance and intensity of training. Some studies have shown a positive effect of different dance styles used in dance sport training programs on improvements in physical fitness (Koutedakis, Jamurtas, 2004). An aerobics and aerobic gymnastics training program was used for the E-2 group, and the boys in this group showed an improvement in their one-foot lengthwise balance test. Balancing ability is one of the main factors that determine technical fitness in sports that demand difficult coordinated movements (Chua, 2014; Hrysomallis, 2011). Dance sport is a noncyclic sport involving a variety of movements and demands on performance quality (Lukić et al., 2012). Static balancing ability enables the maintenance of a constant body position in required postures (Sekulic et al., 2013).

The control group of subjects only participated in the dance sport training program for 12 weeks. Nevertheless, the boys showed significant improvements in their speed endurance plate-tapping test. These improvements might be related to their age range, which corresponds to a period of increased sensitivity for speed development (Mackey et al., 2011; Dawes, Roozen, 2012). According to the literature (Uzunović et al 2009), speed endurance ability is very important in dance sport because dances are performed at intensive tempos of up to 50 measures per minute.

After 12 weeks of education, the indices of dancers' flexibility in the sit-and-reach test, one-foot lengthwise balance test, squat jumping at 90° of knee flexion, and a vertical jump with an arm swing, were increased significantly ($p < .05$) in the E-1 and E-2 groups compared with the control group. At the beginning of this study, no significant differences in physical fitness were found among the groups. Thus, the education programs used for the E-1 and E-2 groups were more effective than in the C group.

5. Conclusion

Our findings confirm the possibility of improvements in young dancers' performance by varying education programs without adding training time. Adding physical training or aerobics plus aerobic gymnastic training resulted in significant improvements in the dance sport performance scores with the same physical fitness results. Dance sport training alone did not improve the performance scores of the control group of dancers. The potential of these study findings should be studied in intervention studies recruiting young dancers from other age groups.

The limitations of this study were that only one age group was studied and only one dance sport teacher was trained in the techniques involved. Future studies should include more age groups and more physical fitness and dance sport teachers of both genders.

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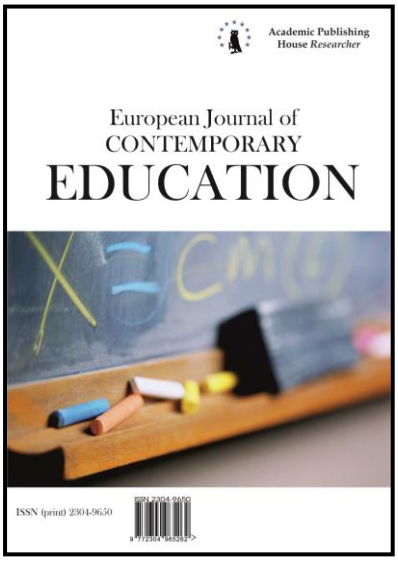

Modernization of Regional Continuing Pedagogical Education in the «School-College-Institute»

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Abstract

The development of a strategy for continuous pedagogical education in the aspect of professional training of students in the direction of "Pedagogical education" contributes to solving the problem of lack of teaching staff in the region, including young graduates. The implementation of this technology involves a wide synergistic interaction of higher education institutions, pedagogical colleges and secondary educational institutions. In this regard, the goal of the research is to develop a structural model for the modernization of regional continuing pedagogical education in the school-college-university system and experimentally prove its effectiveness in the implementation of teacher education in the region. The structural model developed in the study includes synergistically interconnected blocks: regulatory and legislative, targeted, theoretical, methodological, technological, and resulting. The study involved various budget organizations (n = 50) and the pedagogical institute (n = 1) of the Udmurt Republic. The implementation in practice of the model showed its effectiveness at each link in the holistic system of the educational route of the region: from schoolchild to young specialist. The increase in the number of applicants for pedagogical training profiles, the increase in students' motivation from the first to the fifth year to the future professional activity, as well as the directly proportional reduction in the lack of young specialists in this area in the region consistently proves the effectiveness of the study and the need to continue it.

Keywords: system model, continuous pedagogical education, school-college-institute, region, modernization, motivation.

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1. Introduction

Teachers are one of the most popular professions: in the USA there are about 3.4 million primary and secondary school teachers, and in Russia there are almost 1.5 million. Many scientific and sociological works are devoted to the problem of preparing for the most popular profession in Russia and abroad. The studies emphasize that the system of training teachers cannot be built only on the selection of gifted students, it is necessary to learn how to prepare future teachers for professional activities. In this regard, the improvement of the educational system cannot be carried out without the system modernization of teacher education (Sidorkin, 2013). Pedagogical education determines the quality of professional training in all areas of the functioning of society and the state. The implementation of the Bologna and Turin processes in all organizations of secondary vocational and higher education most urgently put forward the task of increasing the competition of educational organizations and the education system as a whole at the regional, federal and international level.

In 2013-2014, according to the results of a sociological survey, it was found that in our country the proportion of teachers over 50 years old (almost 40 %) is significantly higher than the average for other countries participating in the survey. The outflow from the profession of qualified and active young teachers seems to have influenced the age structure of this professional group in post-Soviet Russia (Maslinsky, Ivanyushina, 2016).

In turn, the increase in requirements for teaching staff and the need for pedagogical universities to meet federal target indicators of the effectiveness of educational institutions of higher education, in terms of increasing the number of graduates who are employed in the teaching space, determined the need to develop new professional trajectories based on cluster technologies (Aydarova, 2016). In this regard, the need for the implementation of continuing professional education (Eremenko, 2014; Kurdenkova, 2014; Aleksandrov et al., 2015; Vinogradov et al., 2015; Fedorov, Sedykh, 2015; Yakovleva, 2015; Pushkareva, 2016; Miles et al., 2016; Park et al., 2016; Iwakuni, 2017; Asadullin 2017; Cherednichenko, 2017; Nagovitsyn et al., 2018, etc.) in creating a system of strategic partnership, including the interaction of secondary schools, pedagogical colleges, teacher training institutions, employers and local government authorities and management.

The development of a strategy for continuous pedagogical education in the aspect of professional training of students in the direction of "Pedagogical education" contributes to solving the problem of lack of teaching staff in the region, including young graduates. The implementation of this technology involves a wide synergistic interaction of higher education institutions, pedagogical colleges and secondary educational institutions. The most common model of cooperation is the school-college-university educational cluster model. The need to find new approaches to increasing and further attracting young teachers, educators and teachers to educational activities in various organizations is dictated by key areas stated: in the "Law on Education" in the context of article 46, in the "Professional Standard of Teacher" in the aspect of part 1 on teacher qualification characteristics, in the "Concept of the Federal Target Program for the Development of Education for 2016–2020", in the "Concept for the Long-Term Socio-Economic Development of Russia of the Russian Federation for the period up to 2020", in the "Strategy of the innovative development of the Russian Federation for the period up to 2020", in the State Program of the Russian Federation "Development of Education" for 2013-2020, in the "National Doctrine of Education of the Russian Federation" (2000-2025), in the "Comprehensive Program for the Improvement of the Professional Level of Teachers of General Education Organizations" for 2013-2020.

A detailed analysis of domestic and foreign studies on the research problem revealed the multidimensionality of key decisions on the analyzed topics in the system "student-entrant-student-graduate-young teacher. A number of authors sharply raise issues of improving career guidance activities as the main factor in the system for increasing the quantity and quality of teaching staff (Schleicher, 2011; Bignold, Barbera, 2012; Kasprzhak, 2013; Margolis, 2015 Nagovitsyn et al., 2018, etc.), including a system for upgrading the admission campaign system to pedagogical profiles (Alasheev et al., 2016; Zhuk, 2016; Floden et al., 2017, etc.).

The main task of researchers is most often to justify the ways and possibilities to enhance the training of teachers in continuous systems "college-university" and "school-university" (Volodina et al., 2017; Yuzhaninova, 2014; McMahon et al., 2013; Zeichner, 2012 ; Sobolev, 2016; Miles et al., 2016; Park et al., 2016; Iwakuni, 2017; West, Saine, 2017; Li, 2018, etc.). Also, a number of researchers propose the implementation of the modernization of gradual introduction of graduates of pedagogical profiles into independent professional activities (Trent, 2012; Pereira, 2013; Ovcharov, Lopatkin, 2015; Fedorov, Sedykh, 2015; Zagvyazinsky, 2016; Maslinsky, Ivanyushina, 2016; Pinskaya et al. , 2016; Rijswijk et al., 2016; Adnot et al., 2017; Gafurov et al., 2018, etc.). Particularly noteworthy are the works published abroad and aimed at finding ways to solve the reduction in the quantity and quality of teaching staff observed in Russia (Sabirova, 2014; Sobolev, 2016; Ismagilov et al., 2017).

The analysis and synthesis of various approaches to the modernization of continuing pedagogical education identified in the study, the search for new models for the implementation of teacher training made it possible to identify the key contradiction (Nagovitsyn et al., 2017). Between a thoroughly developed regulatory and theoretical and methodological framework for the modernization of pedagogical education and the inadequate systematic study of each stage of the regional system of continuous professional education of a teacher: a graduate student, a graduate student and a young teacher. In this regard, the goal of the research is to develop a structural model for the modernization of regional continuing pedagogical education in the school-college-university system and experimentally prove its effectiveness in the implementation of teacher education in the region.

2. Materials and methods

The study involved (n = 50) municipal budgetary secondary general education institutions, youth sports schools and institutions of supplementary education in all districts of the Udmurt Republic (focus-organizations). And the only pedagogical educational institution of the Udmurt Republic, which prepares bachelors of pedagogical education – Glazov State Pedagogical Institute. V.G. Korolenko (focus institute). Focus organizations were selected for the experiment based on the availability of information for the study and the presence of working graduates of the focus-institute.

Experimental work was carried out from 2015 to 2018 based on the analysis of the scientific literature, the collection of official information, sociological and comparative methods, questionnaires, interviews, analysis and formulation of the relevant conclusions. For a quantitative analysis of the data obtained in the course of research, the T-test was used at ($p=0.01$, $p=0.05$).

For a sociological analysis, indicators were used in the clusters “student-applicant-student” and “student-young teacher”. For the first cluster, the following criteria were used to identify the percentage:

- applications for admission to the focus-institute from applicants from focus organizations of the total number of applications filed by them;
- incoming applicants to the focus-institute of focus organizations from the total number of entrants received;
- students of 1-2 courses of the focus-institute, who do not want to work according to the profession being taught, of the total number of students of 1-2 courses;
- students of 4-5 courses of the focus-institute who do not want to work in the profession being taught, of the total number of students of 4-5 courses.

For the second cluster, the following criteria were used to identify the percentage:

- the employed graduates of the focus-institute are not in the profile of training or not employed at all from the total number of graduates of this year (military service and a decree are not included);
- free pedagogical vacancies in focus organizations of the total number of pedagogical rates in focus organizations;
- young specialists of focus organizations leaving the profession in the first 3 years after starting work from the total number of teachers in focus organizations;
- young specialists up to 25 years of the total number of working teachers in focus organizations.

For a theoretical research work, we analyzed publications in leading domestic and foreign scientific journals that are part of the Web of Science or Scopus international citation systems for the past 5 years. The national journal selection includes: “European Journal of Contemporary Education”, “Pedagogy”, “Voprosy obrazovaniya”, “Russian Education & Society”, “Integration of

Education", "Novosibirsk State Pedagogical University Bulletin", "Teoriya i praktika fizicheskoy kul'tury", "Psychological science and education". Magazines of the largest publishers were included in the foreign sample: Elsevier Science Publishing Company, Springer Science-Business Media, John Wiley & Sons, Inc., SAGE Publishing and Taylor & Francis Group.

The structural model of modernization of regional continuing pedagogical education in the school-college-university system developed in the study offers the author's view on the improvement of teacher training in the region by level: student-entrant, student-student and young teacher (Figure 1).

Regulatory support of the process of continuous professional training of teachers							
Law on Education	Professional standard of a teacher	Concept of the Federal Target Program for Education Development for 2016–2020	Concept of Long-Term Socio-Economic Development of the Russian Federation for the Period up to 2020.	Strategy of Innovative Development of the Russian Federation for the Period up to 2020.	State Program of the Russian Federation «Develop-ment of Education» for 2013-2020	National Doctrine of Education of the Russian Federation (2000–2025).	A comprehensive program to improve the professional level of teachers in general education organizations for 2013–2020.
The right to engage in teaching activities are persons who have secondary vocational or higher education and meet the qualification requirements specified in the qualification reference books, and (or) professional standards	The teacher must have a higher education; Teachers with secondary special education and currently working in pre-school organizations and elementary school should be given the conditions for obtaining it without separation from their professional activities	Implementation of pilot projects for the modernization of regional vocational education systems and the optimization of vocational education programs, support for the development of associations of educational institutions of vocational education (cluster type) on the basis of universities	Realization of the strategic goal of the state policy in the field of education to increase the availability of quality through the creation of a modern system of continuous education, training and retraining of professional personnel	Development of regional innovation development strategies through building up human resources in science, education, technology and innovation, which, in turn, should be ensured by the creation of a continuing education system	Updating the composition and competencies of teaching staff, creating mechanisms for motivating teachers to improve the quality of work and continuous professional development	Establishes the priority of education in public policy, through the creation of conditions for the steady increase in the prestige and social status of teachers and educators, and the implementation of continuity of levels and levels of education	Increase the prestige of the profession and modernization of pedagogical education, focused on the introduction of models of network interaction of educational organizations, conducting long-term practices, including ensuring the implementation of individual educational trajectories for students who already have secondary vocational or higher education

Regulatory block

Purpose:
Reducing the shortage of teaching staff in organizations of educational, additional, preschool, physical education, sports, creative areas of the region and the care of young teachers from the profession without increasing budget funding and material social investments

↓

Tasks			
Implementation of the network programs of additional education "Young teacher" and teaching classes	Creation of continuous vocational guidance activities of schoolchildren and students for further employment as a teacher, starting from the middle level of the school and ending with the magistracy and postgraduate studies	Improving the continuous training program "Targeted training"	Improving the social status of the future and the young teacher

Target block

↓

Cluster steps of the system of continuous professional education of a teacher						
Schoolboy – enrollee		Enrollee – student		Student – young teacher		
The main directions of theoretical and methodical research on the analysis leading domestic and foreign educational journals						
Improving career guidance activities of potential students of pedagogical profile	Modernization of the admissions campaign system for pedagogical profiles	New approaches to the implementation of teacher training in continuous systems:		Search for ways to address the decline in the quantity and quality of teaching staff observed in the national education system (based on foreign experience)		Development of a system of long-term internship as the final stage of training, postgraduate support, or the creation of specialized "pedagogical residencies"
		"School-university"	"College-university"	Russian studies	Foreign studies	
Schleicher, 2011; Bignold, 2012; Barbera, 2012; Kasprzhak, 2013; Margolis, 2015; Borisenkov, 2015; Zemtsov, 2015; Yeremkin, 2015; Barinova, 2015; Terentyev, 2015; Gruzdev, 2015; Gorbunova, 2015; Aydarova, 2016; Beetle, 2016; Avralev, 2017; Efimova, 2017; Makoveychuk, 2017; Chistyakova, 2017; Rodichev, 2017; Sokolova, 2017; Safronov, 2018; Tyunnikov, 2017; Kass, 2018; Miller, 2018	Kasprzhak, 2013; Kharchenko, 2013. Frumin, 2013; Heinz, 2013; Bolotov, 2014; Havenson, 2014; Solovyov, 2014; Borisenkov, 2015; Terentyev, 2015; Gruzdev, 2013, 2015; Gorbunova, 2013, 2015; Churekova, 2015; Prahov, 2015; Alasheev, 2016; Kogan, 2016; Tyurin, 2016; Beetle, 2016; Richmond 2016; Chehnczyuj, 2017; Floden, 2017; Richmond, 2017; Drake, 2017; Petchauer, 2017	Schleicher, 2011; Watkinson, 2011; Tinoca, 2011; McMahon, 2013; Forde, 2013; Dickson, 2013; Zeichner, 2014; Payne, 2014; Brayko, 2014; Volodina, 2014; Obolonskaya, 2014; Ratt, 2014; Yuzhaninova, 2014; Sergienko, 2015; Vinogradov, 2015; Panfilov, 2015; Panfilova, 2015; Rakhmanov, 2015; Lincove, 2015; Osborne, 2015; Mills 2015; Evagorou, 2015; Dillon, 2015; Viiri, 2015; Albe, 2015; Muskin, 2015; Pisarev, 2016; Srinivasan 2016; Engelbrecht, 2016; Ankiewicz, 2016; West, 2017; Saine, 2017; Li, 2018; Whiting, 2018	Kovaleva, 2011; Denischeva, 2011; Sheveleva, 2011; Li, 2012; Serdenciuc, 2013; Hökkä, 2013; Eteläpelto, 2013; Alexandrov, 2015; Tenisheva, 2015; Savelyev, 2015; Dubrovskaya, 2015; Sparrow, 2016; Saytimova, 2016; Sobolev, 2016; Miles, 2016; Lemon, 2016; Mitchell, 2016; Reid, 2016; Park, 2016; Tandberg, 2016; Shim, 2016; Hu, 2016; Herrington, 2016; Iwakuni, 2017; Asadullin 2017; Cherednichenko, 2017; Nagovitsyn, 2018	Kasprzhak, 2013; Sidorkin 2013; Kharchenko, 2013; Yanbarisova, 2014; Alexandrov, 2015; Margolis, 2015; Tenisheva, 2015; Savelyev, 2015; Borisenkov, 2015; Sergienko, 2015; Pinsk, 2015; Sparrow, 2016; Saytimova, 2016; Aydarova, 2016; Merenkov, 2016; Sushchenko, 2016; Pisarev, 2016	DeCorte, 2014; Sabirova, 2014; Miles, 2016; Lemon, 2016; Mitchell, 2016; Reid, 2016; Karelina, 2016; Sobolev, 2016; Sorokin, 2016; Ismagilov, 2017 Salnikov, 2017; Ger, 2017; Kaizer, 2017; Tyunnikov, 2017; Menter, 2017; Valeeva, 2017; Kalimullin, 2017	Kaplan, 2012; Trent, 2012; Furlong, 2013; Sidorkin 2013; Kharchenko, 2013; Pereira, 2013; Roshchin, 2014; Rudakov, 2014; Ovcharov, 2015; Lopatkin, 2015; Maloshonok, 2015; Semenova, 2015; Terentyev, 2015; Fedorov, 2015; Gray, 2015; Hildenbrand, 2015; Schultz, 2015; Zagvyazinsky, 2016; Maslinsky, 2016; Ivanyushin, 2016; Pinsk, 2016; Ponomareva, 2016; Kosaretsky, 2016; Ilyina, 2016; Solyankina, 2016; Rijswijk, 2016; Akkerman, 2016; Schaap, 2016; Tartwijk, 2016; Reeves, 2016; Lowenhaupt, 2016; Adnot, 2017; Dee, 2017; Katz, 2017; Wyckoff, 2017; Gafurov, 2018; Valeeva, 2018; Kalimullin, 2018; Sakhieva, 2018; Lazarev, 2018; Margolis, 2018; Safronov, 2018; Fedina, 2018; Burmykina, 2018; Lumps, 2018; Kretov, 2018; Bressman, 2018; Hamilton, 2018; O'Dwyer, 2018; Winter, 2018; Efron, 2018

Theoretical methodical block

Implementation technology				
Ministry of Education and Science of the Russian Federation	Governing bodies of the regional education system	School	College of Education	Pedagogical university or faculty
Implementation of the network programs of additional education (PDO) "Young teacher" and teaching classes				
Providing opportunities for students who successfully completed the "Young Teacher" or teaching class to receive a certificate and a certificate for admission to a university or college without exams and the Unified State Examination subject to a special agreement, with the right to teach, combining studies at a university	Creation of pilot general educational organizations and institutions of additional education for the implementation of the Young Teacher circles and pedagogical classes	Implementation of high-quality and high-quantitative recruitment of schoolchildren in the network "Young Teacher" and pedagogical classes	Assistance to vocational guidance on the recruitment and active involvement in the educational process of the (PDO) "Young teacher" and pedagogical classes; training of qualified personnel in the network program of secondary vocational education, undergraduate and magistracy "Additional education in the field of social and educational activities" for work on the programs of additional education (PDO) "Young Teacher" and in teaching classes	
Creation of continuous vocational guidance activities of schoolchildren and students for further employment as a teacher, starting from the middle level of the school and ending with the magistracy and postgraduate studies				

Technological block

Providing the possibility of entering without a unified state examination, graduates of the (PDO) "Young teacher" and teaching classes, subject to admission to the target admission	Postponement from the army of secondary school and higher education graduates who are enrolled in the educational system (in the countryside) under a target agreement	Developing a favorable motivating teenagers to receive the profession of a teacher of the space “Being a modern teacher” of the school through class teachers and administrators	Creation of vocational guidance activities in an educational institution for the further continuation of training graduate students in higher education in the direction of "Pedagogical Education"	The abolition of admission to the exam, graduates of the (PDO) "Young teacher" and teaching classes
Creating a single entrance test (after grades 9 and 11) "Pedagogical education" (instead of the Unified State Exam), included in the monitoring indicator	Creating a regional pedagogical Olympiad for admission to the direction of "Pedagogical Education"			Development of a package of documents and holding of federal and regional pedagogical school olympiads
Creating a list of regional pedagogical Olympiads for schoolchildren and making adjustments to the list of benefits according to the rating approach				

Improving the continuous training program "Targeted training"

Increase the target check digit for the target set to 90%	Establishment of employment monitoring in the teaching profession (MTUP) school graduates in (10%), after graduating from a higher educational institution	Creation of an open municipal and regional information system for obtaining targeted areas	Admission to the budget of applicants who have successfully completed (PDO) "Young teacher" or teaching class without exams and USE subject to the target contract
			Correction of admission provisions for target destinations (90 %)
Cancellation of the monitoring indicator (USE scores) on the target set	Implementation of a public online survey on the motivation to work as a teacher for schoolchildren, students "College-university"	The conclusion of contracts or targeted areas: the enrollee-school-university-employment organization	
		Development of the system of mentoring the future young specialist	Attraction of teachers from the university to the college’s educational activities and, conversely, as part of the implementation of the network form of education
Regulatory legal tightening of compulsory employment in the target area (at least 3 years)	Making adjustments to the regulations on the conduct of the competition "Teacher of the Year" and the certification requirements of teachers based on the indicators of the MTUP and public online survey	Creation of a municipal and regional experimental platform for continuous pedagogical education on the basis of the region	

Improving the social status of the future and the young teacher

Receipt on special quotas only when providing a targeted direction	Creation of a unified information system (municipal and regional) on the social conditions of places for the employment of young professional teachers	Creating conditions for obtaining high-grade high-quality secondary vocational and higher education	
Cancel enrollment without USE college graduates non-pedagogical profile	Creation of conditions for comfortable professional activity of a young teacher	Development of an integrated university curriculum for full-time and distance education on a college-university trajectory, (2 years classroom + 2 years long-term practice with the possibility of employment)	
Providing employment opportunities for students with a certificate of incomplete higher education, subject to continuing education	Exclusion from the university only with a joint commission with representatives of the employer in the target area	Guaranteed budget place in the university subject to the direction of the target and subsequent employment	Development of new curricula for graduates of secondary schools (3 years classroom + 2 years in long-term practice with the possibility of employment)

Technological block

Reducing the lack of high-quality teaching staff in educational, additional, pre-school, physical education, sports, creative areas of the region and leaving young teachers in the profession without increasing budget funding and material social investments

Result block

Fig. 1. Structural model of modernization of regional continuing pedagogical education in the system “school-college-institute”

3. Findings

From 2015 to the present, the developed author's system model is being gradually introduced into the process of training teachers in the Udmurt Republic. The results of its testing by year (2015-2018) for the above-indicated percentage indicators in the clusters "student-applicant-student" and "student-young teacher" are presented in Figures 2-3:

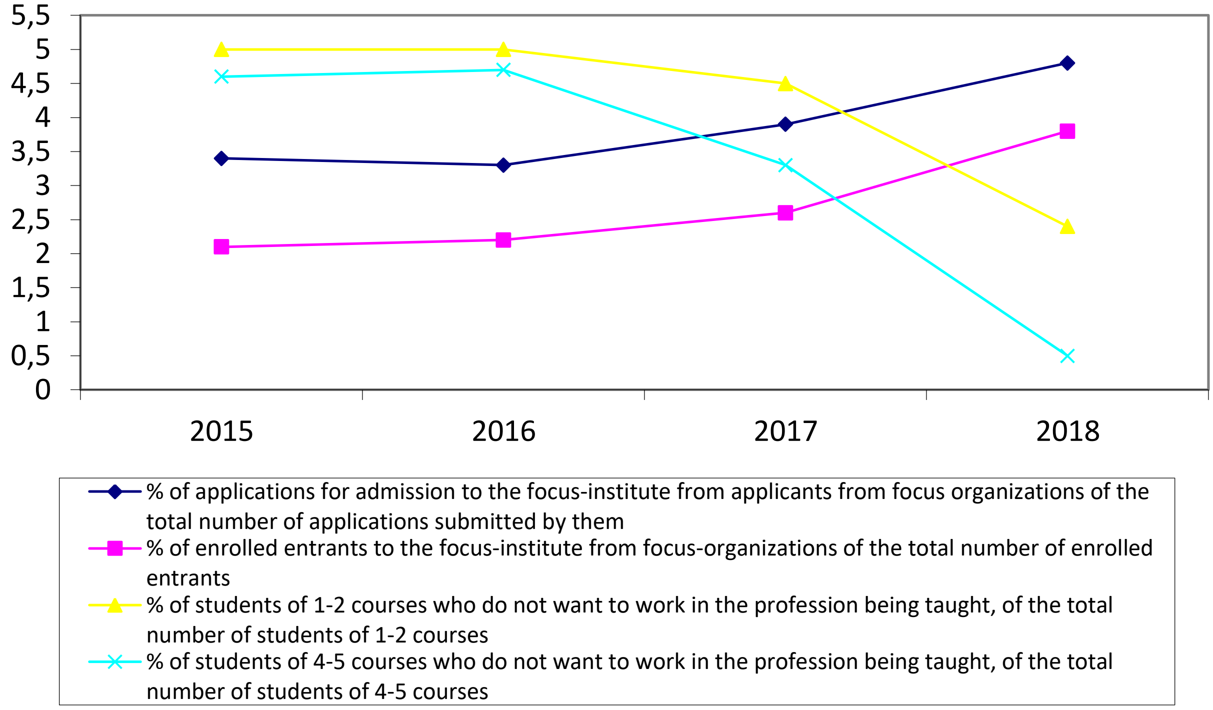

Fig. 2. The results of the introduction of the author's system model in the cluster "student-student-entrant"

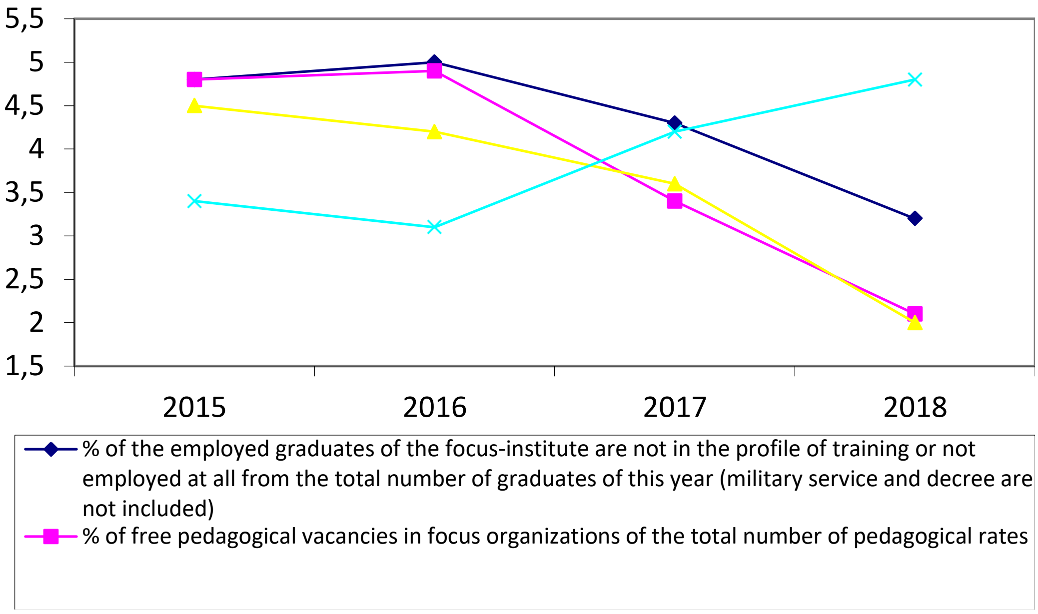

Fig. 3. The results of the introduction of the author's system model in the cluster "student-young teacher"

According to the results of experimental work, it was revealed that the introduction of a structural model for the modernization of regional continuing pedagogical education in the “school-college-university” system is generally effective for the implementation of teacher education in the region.

For a quantitative analysis of the data, it was used ($p = 0.01$ and $p = 0.05$) according to the formula: $t_e = | M\text{-}Z | / \sigma * \sqrt{N}$, where M – the arithmetic average of the studied samples from four values of each analyzed year, Z – a normative indicator with which a comparison takes place (average data taken for the previous 2008-2014 years in the admissions office, at the faculty and in the employment department), N – the volume of the studied sample, σ – the variance of the studied sample. Moreover, the number of degrees of freedom T-test for one sample: $df = 4 - 1 = 3$. To make a reliable statistical decision, the level $p = 0.05$ was determined - the resulting indicator must be $t_e > 3.182$ or the level $p = 0.01$ – the resulting the indicator should be $t_e > 5{,}841$.

As a result of calculations obtained the following data:

- $t_e = 4.81$, which means that the percentage of the number of applications for admission by year to the focus-institute from applicants from focus organizations of the total number of applications submitted by them ($M = 3.85$; $\sigma = 0.686$; $N = 4$) is statistically significant exceeds the average standard indicator at $p = 0.05$, for previous years $Z = 2.2$. Total: $p < 0.05$;

- $t_e = 2$, which means that the percentage of enrolled applicants to the focus-institute of focus organizations from the total number of enrolled applicants by year ($M = 2.68$; $\sigma = 0.78$; $N = 4$) does not statistically significantly exceed the average normative indicator at $p = 0.05$, for previous years $Z = 1.9$. Total: $p > 0.05$;

- $t_e = 3.34$, which means that the percentage of 1-2 focus-institute courses that do not want to work in the profession being taught, of the total number of students, 1-2 courses by year ($M = 4.23$; $\sigma = 1.24$; $N = 4$) statistically significantly exceeds the average standard indicator at $p = 0.05$, for previous years $Z = 6.3$. Total: $p < 0.05$;

- $t_e = 5.85$, which means that the percentage of students in a 4-5 focus-institute course who do not want to work in the profession being taught is 4-5 in the total number of students in a year ($M = 3.27$; $\sigma = 1.96$) ; $N = 4$) statistically significantly exceeds the average standard indicator at $p = 0.01$, for previous years $Z = 9$. Total: $p <0.01$;

- $t_e = 3.38$, which means that the percentage of employed graduates of a focus-institute is not in a training profile or not employed at all from the total number of graduates by year ($M = 4.33$; $\sigma = 0.81$; $N = 4$) is statistically significant exceeds the average standard figure at $p = 0.05$, in previous years $Z = 5.7$. Total: $p < 0.05$;

- t_e = 1.67, which means that the percentage of free pedagogical vacancies in focus organizations of the total number of pedagogical rates in focus organizations by year (M = 3.8; σ = 1.32; N = 4) does not statistically significantly exceed the average standard indicator at p = 0.05, for previous years Z = 4.9. Total: $p > 0.05$;
- t_e = 5.98, which means that the percentage of young specialists in focus organizations leaving the profession in the first 3 years after starting work from the total number of teachers in focus organizations by year (M = 3.58; σ = 1.11; N = 4) statistically significantly exceeds the average standard indicator at p = 0.01, for previous years Z = 6.9. Total: $p < 0.01$;
- t_e = 2.03, which means that the percentage of young specialists up to 25 years of the total number of working teachers in focus organizations by year (M = 3.88; σ = 0.77; N = 4) does not statistically significantly exceed the average standard indicator at p = 0.05, for previous years Z = 3.1. Total: $p > 0.05$.

It should be noted that especially reliable results with p = 0.01 were recorded in the "student-university-student-student" cluster in reducing the number of 4-5-year students who did not want to work in the teaching profession, and in the "student-young teacher" cluster in reducing the number of young professionals in focus organizations leaving the profession in the first 3 years after the start of their professional activities in the field of education and training. Positive reliable shifts were recorded at p = 0.05, both in the increase in the number of applications for enrollment and the total number of focus organizations admitted to the focus-institute, and in the employment of graduates in the field of study. In general, the implementation of the presented model contributed to the filling of free pedagogical vacancies in focus organizations and a significant reduction in the age (rejuvenation) of teaching staff in participating educational institutions.

4. Discussion

The results of research work complement the data of a study on the study of various motives of applicants in choosing pedagogical professions (Kass, Miller, 2018). Scientific work (Eremenko, 2014), which proposes the technology of reducing the term of training in continuing vocational training "college-university" in the educational trajectories of "4 + 2". And also the following results of the research work, where it is proved that the conditions for continuing education in a higher education institution are only for targeted training through building a system of pedagogical education in the form of a model of vertical integration of single-profile educational institutions within a single pedagogical complex (Sergienko, 2015).

In particular, our results reveal the depth to a holistic understanding of the improvement of the admissions campaign in the pedagogical direction: the creation of pedagogical classes, the active involvement of the "Young Teacher" educational programs in the educational process. So in the study (Zhuk, 2016), similar results were obtained: the need to create a system of continuous pedagogical education from school, expressed in purposeful work with high school students to prepare them for the informed choice of the teacher's profession. As well as in the work (Terentiev et al., 2015), in which new principles are proposed for admission to pedagogical universities, "not so much that I will enter where I will go to a budget place, but only where I will work".

In turn, the practical results of this study allow us to expand the possibilities for increasing the effectiveness of vocational training based on the cluster approach. The results of the theoretical study are consistent with the implementation and implementation of the college-university training system (Aleksandrov et al., 2015; Iwakuni, 2017), and the school-university interconnected cluster (Volodina et al., 2017; Vinogradov et al. , 2015; West, Saine, 2017, etc.).

The content of the technological unit developed in the study of the modernization model of regional continuing pedagogical education in the aspect of postgraduate support of graduates of pedagogical profile corresponds to the scientific results (Zagvyazinsky, 2016; Ilyina, Solyankina, 2016; Pinskaya et al., 2016). The studies suggest the creation of special "pedagogical residencies" with experience in the implementation of internship sites, in general, the system of professional adaptation of graduates, starting with the graduation course and ending with the first three years of professional activity in school.

In the study (Khavenson, Solovyova, 2014), based on the analysis of the respondents' performance at five Russian universities, the authors conclude that the predictive ability of the total USE score is acceptable in order to recognize this exam as a valid tool for the selection of applicants. However, the results of our study on the study of students of pedagogical profile prove that there is no pattern in the academic performance of students – future teachers, their further employment in the field of study and individual entrance exam scores in a pedagogical university. It should be noted that even the majority of students who had low ranking indicators for admission, receive higher marks for training and work experience in the training process (Nagovitsyn et al., 2018). On the basis of the obtained comparative research data and practical recommendations for improving the quality of teacher education, which are associated with scientific results (Kasprzhak, 2013; Borisenkov, 2015; Sobolev, 2016) are made.

In general, the results presented in the study prove the need to study the main directions of the modernization of pedagogical education: the implementation of the network of additional education programs (PDO) "Young Teacher" and teaching classes; the creation of continuous vocational guidance activities for schoolchildren and students for further employment as a teacher, beginning with the middle level of the school and ending with the magistracy and postgraduate studies; improvement of the continuous training program "Target training", the creation of a systematic and centralized program to improve the social status of the future and the young teacher. The development of theoretical principles, modeling and conducting a practical block of experimental work proved the effectiveness of the systemic impact on the above directions to the system of pedagogical education in the region.

5. Conclusion

Thus, the study presents the author's vision of the modernization of pedagogical education in the region in the cluster systems “student-entrant” “entrant-student” and “student-young teacher”. The study of the regulatory framework and theoretical and methodological literature on the problems of research allowed to create a system model for the implementation of the main activity processes for the modernization of teacher education in the region. The effectiveness of the introduction of the model is actively increasing from 2015 to 2018 according to the criteria proposed in the study, which are developed on the basis of a comparative analysis of the studied scientific literature and a controversial evaluation of domestic and foreign studies on this topic.

Realization in the practice of authoring allowed to get positive results at each link of the holistic system of the educational route of the region: from schoolchild to young specialist. The increase in the number of applicants for pedagogical training profiles, the increase in students' motivation from the first to the fifth year to future professional activities in the education system and the upbringing of the younger generation, as well as the directly proportional reduction in the shortage of young specialists in this area in various organizations of the region holistically shows the need to continue the author's research. The ongoing study will allow to get more reliable results by 2022, supplement the main directions of the author's model, identify the main regularities of the modernization process and further paradigm strategy of the educational process in the region at all levels of the educational system.

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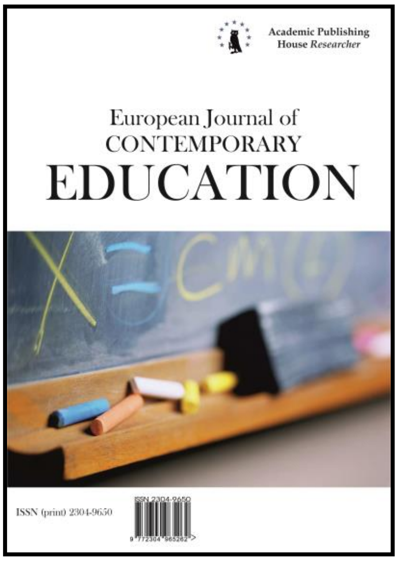

Opinions of Teachers from the Central Slovak Region on Teaching Sports Games at Elementary Schools

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Abstract

This study analyses the opinions of male and female teachers of Physical and Sport Education in the 264 elementary schools from the Central Slovak Region (n = 507, 257 female teachers and 250 male teachers) on the popularity of teaching the sports games thematic unit. These opinions were collected and analysed by questionnaire survey during the school year 2016–2017. Differences of opinions were evaluated from the aspects of gender (male teacher and female teacher) and location (city and countryside). In general, it has been shown that all respondents prefer collective sports, whether in their leisure time or during the class. Artistic gymnastics was ranked as the least popular sport. Several other studies have confirmed that male teachers prefer football while female teachers prefer teaching volleyball. Interestingly, floorball was ranked as the second most popular sport and was ahead of more traditional sports games like basketball. Female teachers firmly refer to football as the least favoured sports game taught in class. The total number of between 11 and 16 hours allocated to the sports games thematic unit is an important finding as well. From the gender aspect, the variance between female and male teachers' answers was statistically significant in terms of popularity and unpopularity of teaching individual types of sports games ($p < 0.01$). From the location aspect, the statistically significant variance at the level of significance was observed only in the female teachers' answers ($p < 0.01$) concerning favouring of a popular thematic unit and unpopularity of teaching specific types of sports games.

Keywords: popularity, physical and sports education, gender, urban and rural schools, sports games thematic unit.

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1. Introduction

In our study, we analysed the opinions of Physical and Sport Education female and male teachers on the popularity of teaching the sports games thematic unit via the comparison of this heterogeneous group from gender and location aspects. Why did we focus on female and male teachers from elementary schools? Why did we focus on teaching the sports games unit? The answer is a new approach to education in Slovakia introduced in 2008. This approach consists of a multi-level state education program. The content of the program at the second stage of elementary schools (lower secondary education) is included in ISCED 2 (Bendíková, 2016). The program offers more opportunities for schools to change according to the conditions, possibilities and needs of the region. The program also offers greater opportunities for self-realization and higher autonomy to teachers and a more creative atmosphere among colleagues. This program was started in 2015 and furthermore, the innovation encourages teachers to prepare interesting lessons for pupils to confirm their knowledge, habits, attitudes and skills about sport, health, and healthy lifestyle. The content of lessons must have equal impact on each pupil. Nowadays, teachers have the option to decide upon the content of education. The main issue is whether they will continue to advocate and force gender stereotypes or will question them and thus open the space for girls and boys to form their own femininity and masculinity.

Soares et al. (2013) identified the influence of gender on motivation in physical education at school. The particularity of the sports games unit was the main aspect that led us to discuss this issue. We focused on recommendations stating that sports games should be included in the physical education curriculum in the highest level (up to 25%) and we also looked at the fact that, according to a number of studies, sports games are the most popular activities with pupils attending elementary schools (Nemec, 2002; Kollár, 2007; Argaj, 2010; Dismore, Bailey, 2011 and others). We may consider the following as the basic reasons behind the popularity of sports games: internal and external motivation, collectivity, clear spatial and time allocation, predetermined rules, high level of rivalry due to the unpredictability of the game's outcome until the end (Adamčák, Kollár, 2003).

The main purpose of sports games is that they help pupils to build a positive attitude towards physical activity. The key factor is to establish a positive attitude towards sports at an earlier stage of development, because the older people become the harder it is to establish firm exercise habits (Sekot, 2009).

Another important feature of sports games is their positive impact on health. According to Krafčík and Görner (2013), regular physical activity improves the body's immune system, circulation of blood, helps to strengthen muscles, reduces the amount of fat in the body (losing excess body weight) and lightens one's mood. According to Ružička et al. (2013), sports games also have a beneficial influence on the development of the pupil's personality and qualities such as self-control, purposefulness, initiative, activeness, tenacity, responsibility and cooperation. The socialization process of the pupil is positively affected by the features mentioned above.

The impact the teachers and schools have on pupils is indisputable. Children spend a large part of the day at school. The school has to provide pupils with the necessary information and involve them in activities that will effectively shape their attitudes and develop a healthy lifestyle (Fox, 2004; Sharma, 2006; Marttinen et al., 2018).

Various reports and research show a number of alarming and negative information concerning people's health in general. The Status Report on Enforcing Children's Rights in Slovakia from 2008 reports that youth mostly engage in listening to music, watching television and attending get-togethers in pairs or informal groups (Guráň, 2008).

The results of the international HBSC study (Health Behaviour in School), edited by Currie et al. (2012), point to the fact that a large number of school age children do not engage in sufficient physical activities. Antala et al. (2014) report that physical activity of US citizens is on the decline and has dropped by 32 % over the last 40 years and is expected to drop by as much as 46 % by 2030. Between 1991 and 2009, physical activity in China dropped by 45 % and the drop of physical activity is expected to reach 51 % by 2030. In the United Kingdom, obesity among children aged 2 to 10 increased by 56% between 1994 and 2008. It is shocking that a lack of physical activity accounts for up to 9 % of all deaths in the world. For these reasons, it is important to draw attention to the importance of active lifestyle as a form of disorder prevention. School and teachers are irreplaceable when it comes to dealing with this issue.

In the light of these facts, the main objective of our study was to analyse the differences in the views of Physical and Sport Education teachers teaching at the second stage of elementary schools in the Central Slovakia Region on the popularity of teaching the sports games thematic unit.

2. Materials and Methods

The group of the respondents of the research consisted of 507 physical and sport education teachers of the second stage of 156 urban and 108 rural elementary schools from the Central Slovak Region. To select elementary schools for the research we used a random selection method.

Number of teachers from urban elementary schools was 216 (114 male and 102 female teachers) and from rural elementary schools was 291 (136 male and 155 female teachers). Average age of male teachers from urban elementary schools was 40.32 ± 0.35 years and female teachers was 42.15 ± 0.42 years. Average age of male teachers from rural elementary schools was 44.72 ± 0.38 years and female teachers was 46.25 ± 0.52 years. Figure 1 presents the primary characteristic of the respondents of the research.

The main research method was questionnaire survey. In the questionnaire, we followed the questions used in the research by Nader et al. (2008) and Bendíková (2016). The questionnaire consisted of 8 questions. The respondents wrote their answers on pre-printed forms. The survey was conducted during the school year 2016–2017.

Data analysis – respondents' responses were evaluated from two aspects:

1 / – gender differences in opinions (female and male teachers);

2 / – location aspect (urban and rural schools).

The results were expressed as a percentage number. The statistical analysis was performed using the TAP 3 software. The differences were evaluated using the Chi-square test. The level of statistical significance was set to $p < 0.01$ and $p < 0.05$.

3. Results

The questions number 1 and number 2 concerned the primary characteristics of the respondents of the research (Figure 1).

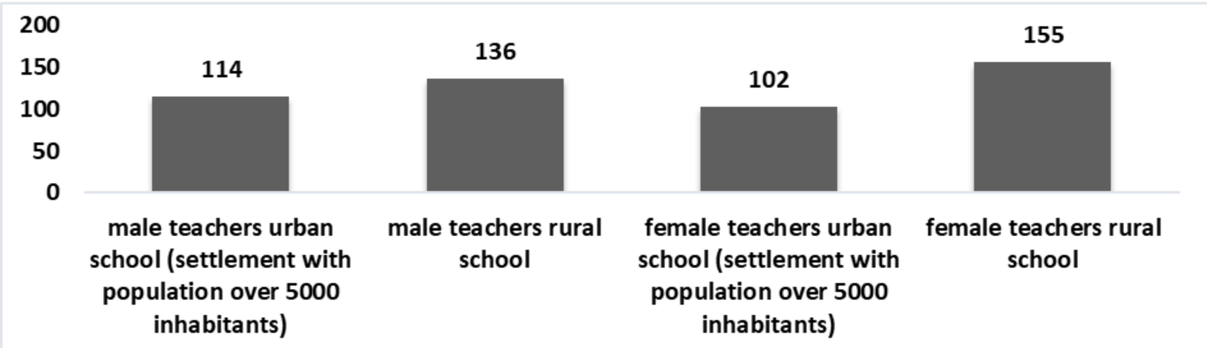


Fig. 1. Primary characteristics of the respondents of the research (n = 507)
Source: own

The third question targeted sports favoured by respondents in their leisure time (Figure 2).

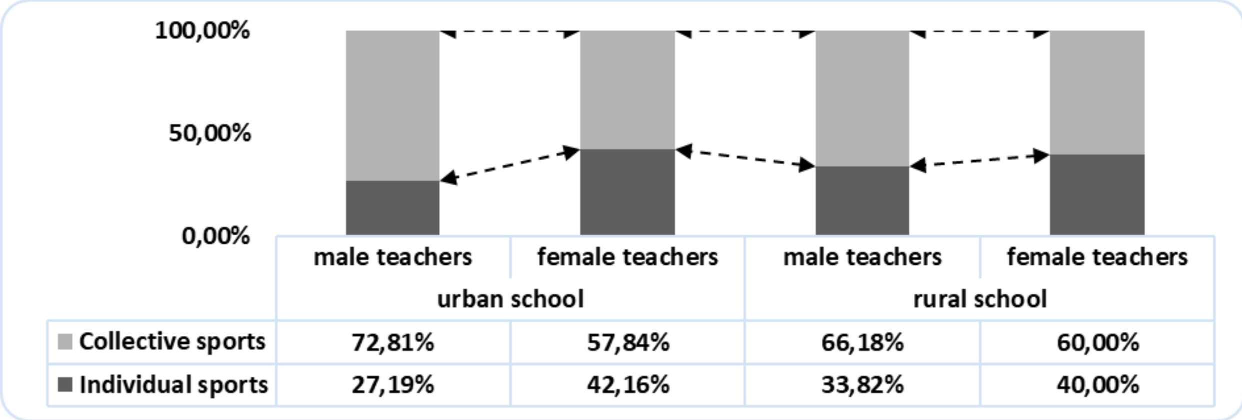


Fig. 2. Sports favoured by respondents in their leisure time
Source: own

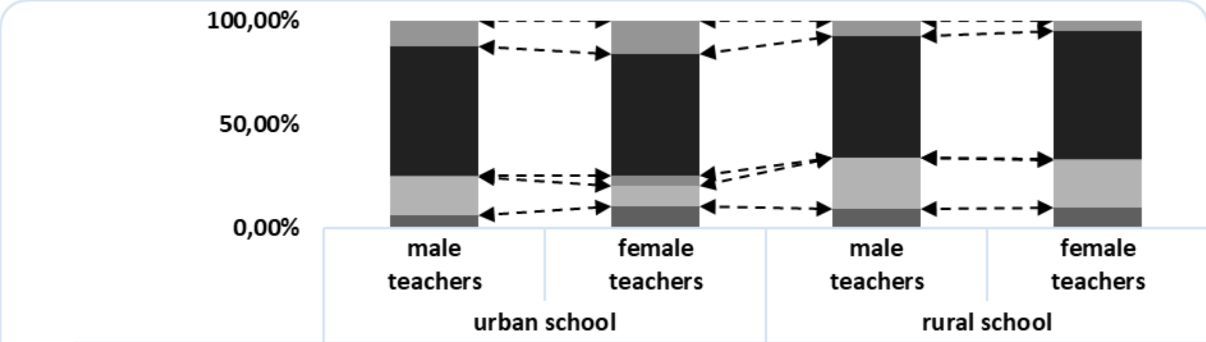
We have found that all respondents prefer collective sports. The collective sports are mostly favoured by urban school male teachers (72.81 %), on the other hand, collective sports are the least favoured unit of urban school female teachers (42.16 %). A statistically significant variance was observed in female and male teachers' answers on third question at the level of significance $p < 0.05$ (Table 1).

Table 1. Statistical evaluation of variance in respondents' answers (Chi-square test)

	Male/Female teachers	Male teachers urban/rural schools	Female teachers urban/rural schools
QUESTION 3	* p= 0,0182	p= 0,258	p= 0,7307
QUESTION 4	p= 0,2871	p= 0,3116	** p= 0,0005
QUESTION 5	p= 0,4377	p= 0,8985	p= 0,2928
QUESTION 6	** p= 9,667 E-14	p= 0,2348	** p= 0,0015
QUESTION7	** p= 4,56 E-16	p= 0,7046	p= 0,1085
QUESTION 8	** p= 0,0133	p= 0,1972	p= 0,4079

Explanatory notes: statistical significance – $p < 0.01$ **, $p < 0.05$*

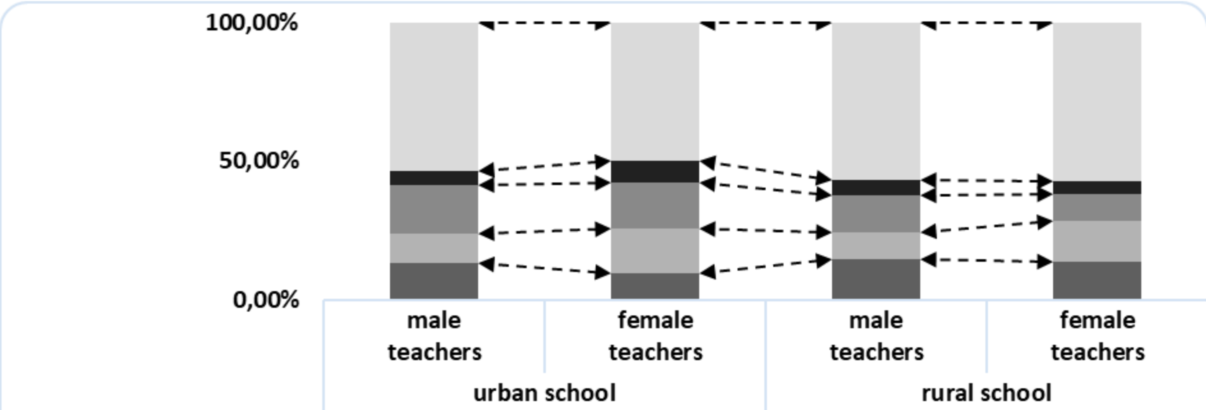
Subsequently, we analysed whether the respondents agreed to give preference to teaching a specific thematic unit on Physical and Sport Education lessons. It is evident from Figure 3 that all respondents prefer practicing collective sports, i.e. sports games (over 58 %), both in their leisure time and during the class. Male teachers from both urban and rural schools ranked athletics as the second most favoured unit to teach. Female teachers from urban schools prefer teaching artistic gymnastics after sports games (15.69 %), while rural schools female teachers favour athletics. A statistically significant variance was observed only in the answers from urban and rural school female teachers on fourth question at the level of significance $p < 0.01$ (Table 1).



	urban school: male teachers	urban school: female teachers	rural school: male teachers	rural school: female teachers
Artistic Gymnastics	12,28%	15,69%	7,35%	4,52%
Sports games	62,28%	58,82%	58,82%	61,94%
Other	0,88%	4,90%	0,00%	0,65%
Athletics	18,42%	9,80%	24,26%	23,23%
Outdoor activities	6,14%	10,78%	9,56%	9,68%

Fig. 3. The most favoured sports taught by respondents
Source: own

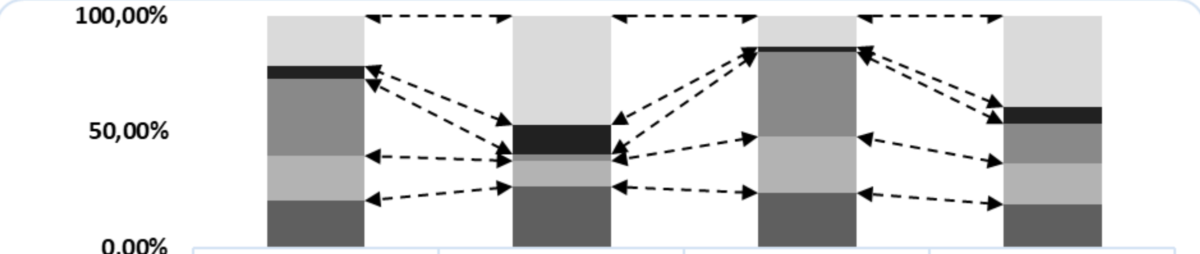
The preceding results on favoured sport were mirrored in the question concerning the least favoured sport (Figure 4) as all respondents do not favour teaching artistic gymnastics (more than 50 % of answers). Artistic gymnastics was followed by the option in which teachers had an opportunity to give an example. Male teachers from urban and rural schools mostly mentioned combat sports. Female teachers from urban schools ranked outdoor activities as the second least favoured unit while female teachers from rural schools ranked athletics as the second least favoured unit. We did not observe any statistically significant variance in the answers on fifth question (Table 1).



	urban school: male teachers	urban school: female teachers	rural school: male teachers	rural school: female teachers
Artistic gymnastics	53,51%	50,00%	56,62%	57,42%
Sports games	5,26%	7,84%	5,88%	4,52%
Other	17,54%	16,67%	13,24%	9,68%
Athletics	10,53%	15,69%	9,56%	14,84%
Outdoor activities	13,16%	9,80%	14,71%	13,55%

Fig. 4. The least favoured sports taught by respondents
Source: own

The following two questions were focused on a more detailed specification of the respondents' opinion from the perspective of taught sports games. We researched the popularity of sports games (Figure 5).

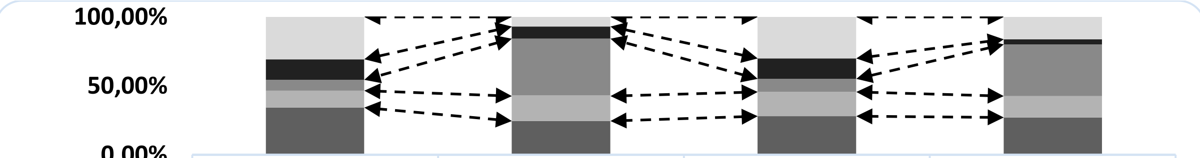


	urban schoool		rural school	
	male teachers	female teachers	male teachers	female teachers
Volleyball	21,93%	47,06%	13,24%	39,35%
Other	5,26%	12,75%	2,21%	7,10%
Football	33,33%	2,94%	36,76%	17,42%
Floorball	19,30%	10,78%	24,26%	17,42%
Basketball	20,18%	26,47%	23,53%	18,71%

Fig. 5. The most favoured sports game taught by respondents
Source: own

The most popular sports game taught and favoured by male teachers from both urban and rural schools is football, which accounted for more than 33 % of respondents' answers. Female teachers chose volleyball as their favourite taught sports game, accounting for 47.06 % of the respondents' answers in urban schools and 39.35 % in rural schools. Statistical variance was observed in the answers from both male and female teachers. We observed statistical variance in the answers from female teachers teaching at urban and rural schools on sixth question at the level of significance $p < 0.01$ (Table 1).

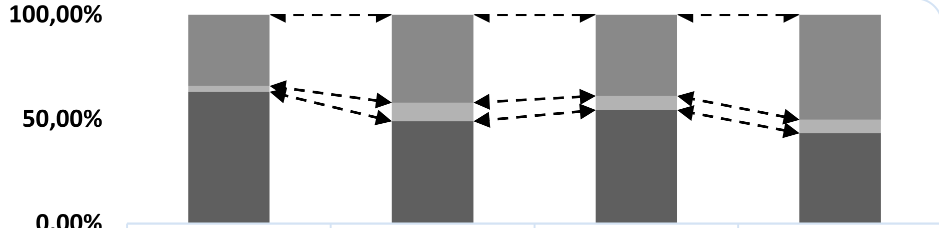
The least favoured sports game taught by male teachers in urban schools is basketball (34.21 %). Volleyball is the least popular sports game taught by male teachers in rural schools (30.15 %). Female teachers in both observed groups ranked football as their least favourite sports game to teach (Figure 6). We observed statistical variance in the answers from both male and female teachers on seventh question at the level of significance $p < 0.01$ (Table 1).



	urban school		rural school	
	male teachers	female teachers	male teachers	female teachers
Volleyball	30,70%	6,86%	30,15%	16,13%
Other	14,91%	8,82%	14,71%	3,87%
Football	7,89%	41,18%	9,56%	37,42%
Floorball	12,28%	18,63%	17,65%	15,48%
Basketball	34,21%	24,51%	27,94%	27,10%

Fig. 6. The least favoured sports game taught by respondents
Source: own

In conclusion, we wanted to learn the preferred total number of hours allocated to teaching the sports games unit by respondents (Figure 7).



	male teachers	female teachers	male teachers	female teachers
	urban school		rural school	
up to 10 hours	34,21%	42,16%	38,97%	50,32%
17 and more hours	2,63%	8,82%	6,62%	6,45%
11 – 16 hours	63,16%	49,02%	54,41%	43,23%

Fig. 7. Total number of hours allocated to teaching sports games unit by respondents
Source: own

Male teachers from rural and urban schools and female teachers from urban schools mostly checked the option eleven to sixteen hours. Female teachers from rural schools commonly allocate up to ten hours to the sports games thematic unit. We observed statistical variance in the answers from male and female teachers on eights question at the level of significance $p < 0.01$ (Table 1).

4. Discussion

In schools education, Physical and Sport Education is perceived as an essential factor in encouraging and developing effective motor skills in pupils and a major factor in primary health prevention. The partial freedom in choosing the content of the curriculum, various interests, values and practical experience formulated into the answers of the observed group of lower secondary education teachers from the Central Slovak Region revealed several intriguing facts. By comparing the opinions of respondents with regard to teaching their favoured sports games strand we may conclude that there is no gender-specific difference involved in favouring one particular sports game. Both observed groups favour collective sports in their leisure time and while teaching at the school. These findings are in line with the findings of other scholars (Nemec, 2002; Vilímová, Hurychvá, 2003; Argaj, 2010; Antala et al., 2014 and others). The least favoured sport in school education that is considered as an unpopular unit of physical education by both the teachers and pupils is artistic gymnastics (Nemec, Adamčák, 2013).

While researching sports games' popularity, we validated findings from numerous preceding studies (e.g. Dismore, Bailey, 2011) reporting that the male teachers prefer teaching football, whereas female teachers are in favour of volleyball. Both sports games are the pillars of Physical and Sport Education classes and significantly mirror the gender-specific perspective on the curriculum contents. Football revolves around direct physical contact and battles between players, features typical for boys. On the other hand, volleyball is perceived as a relatively calm sport in which two teams are separated by a net. These findings also correlate with the interests of the pupils themselves.

The sports games predominate during Physical and Sport Education classes in school but also in their spare time (Frömel et al., 2002; Antala et al., 2014 and others). Fahey et al. (2005) report that the pupils from Ireland favour football, basketball and badminton in the Physical Education classes. It is interesting that floorball was ranked as the second most favoured sports game in the region compared to other traditional sports games like basketball. According to the research of Bendíková (2016), floorball is the most favoured sports game of pupils. As for teachers, we did not observe any difference when comparing the answers on the popularity of sports games teaching. Female teachers clearly present football as the least favoured sports game added to the curriculum.

This difference in opinions on the popularity and unpopularity of teaching sports games is also confirmed by Špaldoň (2017) in research carried out in an elementary school in Western

Slovakia (n=104). He found out that male teachers favour teaching football and floorball, while the female teachers favour volleyball. The least favoured games of male teachers are volleyball and basketball, the least favoured games of female teachers are football and basketball. An interesting finding is the total numbers of hours allocated to teaching the sports games unit.

The total number of 11 to 16 hours corresponds with given recommendations on allocated time to specific units of Physical and Sport Education (Petlák, 2004; Fryková, 2012) and is in line with the findings of Nemec and Kollár (2012), who analysed opinions of elementary school teachers (n= 202) from the North Regions of Slovakia (the Žilina Region). They discovered that 70.3 % of observed schools allocate 16 hours to the sports games thematic unit (football). In our opinion, the total number of 16 teaching hours ensures physical activity to a large extent and can motivate pupils to exercise.

An important fact is that we are talking about highly popular physical activities from which the pupils can greatly benefit as far as their health and overall development is concerned. Devahl et al. (2006) also report that pupils' interest in physical activity is increased by regularly offering of physical activities at school. Just like Sekot (2003), we assume that the following research carried out worldwide must deal with the issues of physical activity motivation and issues of performing such activities with the accent on the issues of motivation in the school context. The motive behind such research is the fact that the motivation to exercise can reach pupils through a plethora of stimuli. School, family, peers, social circumstances, but also stimuli from Physical and Sport Education teachers.

Taking the statistically significant variance of the specific groups of respondents into account and considering the gender aspect, we noticed differences between the answers of male and female teachers to questions 6 and 7 regarding popularity and unpopularity of teaching sports games at the level of significance $p < 0.01$ (p= 9.66 E-14 and p= 4.56 E-16). As we mentioned in the previous text, the gender-specific stereotype is still present even in this region of Slovakia with both male and female teachers having distinct opinions on teaching specific units of Physical and Sports Education (Constantinides et al., 2013). We observed a statistical variance on the level of significance $p < 0.01$ in the opinions of male and female teachers concerning the total number of allocated hours to teaching sports games strand (p= 0.0133). Continuing differences in male-female perspective on teaching the Physical and Sport Education classes remain noticeable in the mixed education of Physical and Sports Education (boys – girls). There are several deciding factors and the motivation factor is certainly one of them.

Many kinds of research highlight the differences in the physical activity motivation in different genders, ages, frequency and length of performing physical activity (Moreno et al., 2010; Verloigne et al., 2011). Egli et al. (2011) report that the inner motivation to win and to be recognized is innate to adolescent boys, whereas in case of girls we are talking about external motivation, mainly their physical appearance and weight. We observed a statistically significant variance at the level of significance $p < 0.05$ (p= 0.0182) in opinions of male and female teachers in question 3 (favouring of sports in respondents' spare time).

From the location aspect (urban-rural schools), we observed a statistically significant variance at the level of significance $p < 0.01$ (p= 0.0182) in two cases. Question 4 (p= 0.0005) concerned favouring specific unit during Physical and Sports Education classes by teachers. Female teachers from rural schools and female teachers from urban schools ranked athletics and artistic gymnastics as the second most favoured units respectively. Answers to question 6 (p= 0.0015) also show that female teachers from rural schools favoured football more frequently as opposed to female teachers from urban schools. We did not observe any statistically significant variances in the opinions of male teachers when reviewing the location aspect. We can say that the location aspect does not play an important role in education. With respect to these findings, we think that the quality and content of the Physical and Sport Education classes are more likely to be improved by using better training equipment and better space dimensions.

5. Conclusion

The task of all Physical and Sports Education teachers is to thoroughly prepare the kind of teaching programme that will comply with the main aims of education, healthy development of pupils, their interests but also with the requirements set by the school. We found that these factors do not depend only on pedagogical mastery, quality, creativity and activity of teachers, but also on the gender and surroundings. For all that, we must advocate that Physical and Sports Education teachers are not just teachers. Most importantly, they should be supportive individuals and should motivate the pupils.

During the course of this research, we were able to gather a lot of interesting and helpful facts from our respondents, active teachers, on the topic of Physical and Sports Education. Apart from the gender difference in favouring specific sports games, we were able to validate previous findings stating that sports games are the most popular and the most frequently included unit in the Physical and Sports Education curriculum framework.

It is a positive fact, mainly if you realise that by including and teaching sports games in the educational process we are drawing nearer to living up to Komenský's idea – school by play. Playing is much more popular with pupils compared to other types of physical and cognitive activities that often involve passive processing of the information. Adequately devised play and sports activities have effective educational, ethical, relaxing and mainly health benefits. Physical and Sports Education classes currently constitute 5-8 % of the total number of teaching hours in the elementary education in Slovakia in favour of physical activity against sitting at the school desk. Such situation is still nowhere close to the Kalos khagatos harmony principle, the unity of healthy soul and body or the harmony of one's existence.

We are aware that our findings cover only a specific part of education, but at the same time, they highlight numerous facts that need to be taken into account if we want to improve the quality and quantity of physical activity in youngsters. In conclusion, we would like to highly recommend something – Physical and Sports Education teachers should pay more attention to encouraging and motivating the pupils (and themselves) to engage in preferred, appropriate and healthy physical activities. Sports games are definitely among them.

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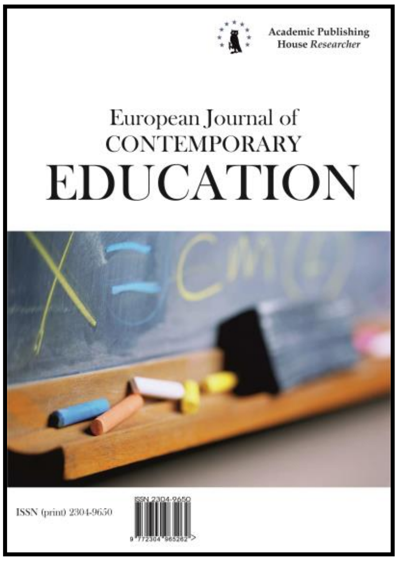

The Model of the Emotionally-Valuable Component of the Content of Primary School Foreign-Language Education: Designing and Testing

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Abstract

The purpose of this article is to develop and test an invariant of the basic model of the emotionally-valuable component (EVC) of the content of foreign-language education, allowing the implementation of this component at a primary stage in a secondary school (grades 2–4)[*]. The leading approach to the study is emotionally-valuable, the methods are systemic-structural, comparative, organizational-functional; designing, modelling; experimental teaching; mathematical statistics; tabular and graphical representation of information. The use of the presented complex of complementary methods allowed us to solve all the problems of the study, namely: to present the concept of a foreign-language text of emotionally-valuable content; to select a specific type of such texts for inclusion in the model of the EVC in the conditions of primary foreign-language education; to describe the techniques of working with texts of emotionally-valuable contents at a primary stage in a secondary school and, finally, to design and test the model of the EVC, adapted to the conditions of teaching a foreign language in a primary school. The results of the study prove the expediency of including the EVC in the component structure of the content of foreign-language education and the construction of its models not only for a primary level, but, in in perspective, for all stages of school foreign-language education. The novelty of the work consists in the substantiation of the author's concept of the EVC as the basis for the introduction of the emotionally-valuable approach in the practice of school-foreign language education.

Keywords: the emotionally-valuable component (EVC) of the content of foreign-language education, a model, designing, testing.

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[*] In this article, the concepts «the invariant of the basic model of the EVC of foreign-language education, adapted to the conditions of a junior level in a secondary school" and "the model of the EVC of the content of primary school foreign-language education" are used as synonyms.

1. Introduction

With the declaration of principles of humanization and democratization of education in the 1990–s the first state standards of education began to be developed. However, only the third generation of standards, currently in force, recorded changes in the content of foreign-language education which occurred as a result of school reform. The federal component of the state standard of secondary (complete) education assumes that the mandatory minimum content of basic educational programs in any subject, including a foreign language, comprises the basic values and achievements of national and world culture, fundamental scientific ideas and facts that determine a person's general worldview and provide conditions for students' socialization, intellectual and cultural development, the formation of their social and functional literacy (Collection…, 2008).

Thus, the content of modern foreign-language education involves not only the mastery of the linguistic code, but also the formation of value orientations at students' entry in a different socio-cultural space and their comprehension of another picture of the world. Changes and additions to the content of foreign-language education at various levels in a secondary school should be aimed at the formation of a student's multicultural linguistic personality (Karaulov, 2010; Khalyapina, 2006, etc.) in the aggregate of his intellectual, volitional and emotionally-valuable spheres. The study of the examples of structuring the content of general (Lerner, 2002) and foreign-language education (Bim, 2005; Nikitenko, 2011; Passov, 2010) also shows that for many researchers it is indisputable that its component composition should include not only knowledge and skill components, but also a certain extralinguistic factor: spiritual values, culture, non-verbal means of communication. In the works of a number of scientists this component is called emotionally-valuable (EVC). In our research the EVC is presented as a set of valuable, emotional, volitional subcomponents and their constituents, as well as personal universal educational actions (UEA) (Tatarinova, 2016).

The purpose of the EVC is to create an organic connection between the "ratio" – "intellectual" components of the content of education and the formation of a student as a multicultural linguistic personality's emotionally-valuable attitude to educational material and the world. The above is due to the need to overcome dangerous technocratic trends and, in the figurative expression of E.G. Tareva, to shift "from the pedestal" the idea of primacy of knowledge, speech skills, topics and areas of communication, etc. (Tareva, 2014). This requires the creation of the basic model of the component which was presented in our earlier studies (Tatarinova, 2014), and on its basis – the invariants of the model for different stages of school foreign-language education. The latter should be potentially ready for functioning at any time of an educational process to master a foreign-language culture.

The article attempts to develop and test the author's invariant of the model that allows the implementation of the EVC of the content of foreign-language education at a primary stage in a secondary school.

2. Materials and methods

In accordance with the personality-oriented paradigm which is regarded as a methodological basis for the modernization of the content of foreign-language education, as a way to its humanization, to taking into account an increasing role of a human factor in it, the approaches to the study are: emotionally-valuable (the leading approach), as well as personal-activity, socio-cultural, etc.

The object of this study is a foreign-language educational process in a primary school. The subject of the research is the model of EVC of the content of primary school foreign-language education. A set of complementary methods was used in the research: a) systemic-structural, comparative, organizational-functional; b) designing, modelling; c) experimental teaching; mathematical statistics; d) tabular and graphical representation of information. The practical implementation of the EVC involves working with foreign-language texts of emotionally-valuable contents. That is why, having set a goal to design and test the model of EVC of the content of primary foreign-language education, the following specific objectives of the study were identified:

1) to define the concept "a foreign-language text of emotionally-valuable contents" as the main unit of the content of foreign-language education and the implementation of its EVC;

2) to substantiate the choice of the type of texts of emotionally-valuable content for inclusion in the invariant of the basic model of the EVC of foreign-language education, adapted to the conditions of a junior level in a secondary school;

3) to describe the techniques of working with foreign-language texts of emotionally-valuable contents in a primary school;

4) to present the invariant of the basic model of the EVC of foreign-language education, adapted to the conditions of a junior level in a secondary school;

5) to test the model of the EVC of the content of primary school foreign-language education.

The theoretical-methodological basis of the study was determined

– by research in axiology, philosophical and psychological-pedagogical concepts of values (Galskova, Tareva, 2012; Passov, 2010; Russell, 2012);

– by the conceptual ideas about the dialectical unity of rational and emotional in the mental development of a personality (Bar-On, 2006; Breslav, 2004; Goleman, 2008; Yanovskaya, 2008, etc.);

– by the concept of a multicultural linguistic personality that will be capable of an active and productive life in a global multicultural society. Such a personality is conscripted to have a developed sense of understanding and respect for other cultures, the ability to live in peace and harmony with people as representatives of different linguistic and cultural groups (Karaulov, 2010; Khalyapina, 2006);

– by works in the field of designing and implementation of a modern foreign-language education, evaluation of its quality (Biboltova et al., 2013; Bim, 2005; Nikitenko, 2011; Passov, 2010; Addick, 2002);

– by research, covering the problems of teaching a foreign language as a means of intercultural communication, a way of learning the achievements of national and universal culture, understanding oneself as a citizen of one's own country and a member of the world community (Nikitenko, 2010; 2011; Tareva, 2014; Knapp-Potthoff, 1997).

Experimental work, aimed at achieving the goal of the study, was carried out in accordance with the requirements for this method of research in psychological and pedagogical literature (Batrakova, 2016; Biborodova, Chernyavskaya, 2014; Sidenko, 2000) and methodological works (Kuklina, 2009; Lyakhovitsky, 1981; Shamov, 2014).

The study involved the students of grade 3 "a " of Kirov regional state educational autonomous institution "Lyceum of natural sciences" (13 pupils) and grade 3 "b" of Kirov regional state educational budgetary institution "Secondary school with advanced study of some subjects of the town of Nolinsk" (12 pupils).). Thus, the volume of our sample was small (the number of participants was 25, i.e. fewer than 30). It was limited by the number of pupils in grades 3 "a" and 3 "b" of the above mentioned schools of Kirov Region that agreed to take part in the experiment. However, since a sample size depends on the statistical methods to be applied, those ones were selected that can be used with a relatively small number of testees (Methods…, 2014). In particular, this concerns to Fisher exact probability criterion. In addition, when evaluating the results of a small sample, corrected sample dispersion was additionally calculated in the study[*].

Anyway, in accordance with the requirement of the criterion of representativeness, the experimental groups of the small sample qualitatively and proportionally reflected the essential types of the general totality of students. To achieve representativeness, a set of the following ways was used:

- stratometric selection. The general totality was interpreted as a certain number of groups with specific characteristics (age, status, level of learning a foreign language and development of the qualities of a multicultural linguistic personality). Thus, in compliance with the purpose of the study, the experimental selection included students of the junior level of school foreign-language education;
- involvement in the experiment of really existing groups. It was assumed that these groups were representative.

In addition to the criterion of representativeness to form the experimental selection the following criteria were taken into account:

[*] In accordance with the logic of presentation of the article, the procedures for statistical processing of the study results will be presented further in the investigation.

– the content criterion (the criterion of operational validity), in conformity with which the indicators of the level of a multicultural linguistic personality's formation were studied for students of a secondary school;

– the criterion of selection equivalency (the internal validity criterion): the obtained results were applied to each member of the selectin. This became achievable as its participants (students) did not differ from each other in significant characteristics (they were equivalent).

The objectives of the pilot study identified the need to include two stages in it. The first of them performed a diagnostic function (Sidenko, 2000) and entailed *a stating type of experiment* on studying the existing conditions for mastering the EVC of the content of foreign language education by students (Biborodova, Chernyavskaya, 2014).

In the course of the study the methodological characteristics of groups (MCG) were compiled, which implied the creation of a diagnostic system, including the indicators of students' mastery of the content of foreign-language education within its "intellectual" components and the EVC. Each MCG was presented in the form of a table in which the horizontal information was about the properties of a student as a multicultural linguistic personality, and vertically there were the students' names (Table 1):

Table 1. Methodological characteristics of the group from the standpoint of a student as a multicultural linguistic personality's development

Students' codes	Traits of a multicultural linguistic personality					
	The level of key competences in the field of foreign-language education	The level of development of the system of the nationwide and universal values	The level of development of personal UEA	The level of development of volitional sphere	The level of development of emotional competence and emotional intelligence	**The total result of mastering the EVC of the content of foreign-language education**
	1	2	3	4	5	**6**

Column 1 contains data on level of students' mastering the key competences in the field of foreign-language education. The objects of diagnosis are the results of the text stage of teaching speaking as the leading type of foreign-language speech activities in a primary school.

To ensure the ease of processing and interpretation of the results, as well as to make statistical conclusions about them, S.S. Kuklina rightly notes that the selected criteria should be measurable and expressed in the same units (Kuklina, 2009). The indicator, demonstrating the level of a student's proficiency in foreign-language speaking, the success rate was used (V.P. Bespalko, A.N. Shamov). It was calculated by the following formula:

$$R_s = \frac{a}{n} \qquad (1)$$

where R_s is the success rate, a is the number of scored points, and n is the maximum possible number of points (Shamov, 2014).

We chose the lower index of the coefficient as 0.7, corresponding to the number of points 13–14 and the school mark "3" as the minimum index of R_s, ensuring a sufficient quality of students' key competences in the field of foreign-language education:

• low: 0.7 and less;
• medium: 0.8;
• high: 0.9–1.

Let us proceed to the description of diagnostic methods for assessing the level of mastery of the EVC of the content of foreign-language education. We start with the level of development of the system of national and universal values **(column 2).** For this purpose, we developed the procedure "Determining the level of development of the system of national and universal values in a foreign-language lesson" for students of different age groups. In the content of the procedure national and universal values, reflected in the program requirements for a foreign language and in the subject content of the educational-methodical complex, were included.

In **column 3** the indicators of the level of development of students' personal UEA are presented. In particular, for personal UEA of self-determination and sense formation the modified procedure "Who am I?" was used (the modification of the technique of T. S. Kuhn). For actions of moral and ethical evaluation the diagnostic procedure "Unfinished sentences" was applied (Program…., 2012).

The parameters of development of a student's volitional sphere are displayed in **column 4.** They were determined with the help of the test-questionnaire by A.V. Zverkov and E.V. Eidman "The study of volitional self-regulation" (Test-questionnaire…). To determine the level of development of primary schoolchildren's emotional competence and emotional intelligence (**column 5**) the diagnostic technique "Three desires" was implemented (Training program…, 2016).

Column 6 contains the total result of mastering the EVC of the content of foreign-language education. It summarizes the data from columns 2–5.

The second stage of experimental work is *the formative experiment* in which, as stated by L.V. Bayborodova and A.P. Chernyavskaya, the introduction of a new factor (new means, techniques, forms, methods, technologies, etc.) takes place, and the effectiveness (or applicability, optimality, availability) of its usage is determined (Biborodova, Chernyavskaya, 2014). This stage involves the use of methods of experimental training, aimed at testing the model of the EVC of the content of primary foreign-language education.

The formative experiment began with the phase of *organization* which, according to M.V. Lyakhovitsky, covers a number of steps (Lyakhovitsky, 1981). Its first step was the preparation of experimental materials: texts of emotionally-valuable contents and techniques of working with them as tools of implementing the EVC, as well as means of monitoring and recording the results of the study (Kuklina, 2009). In the selection of texts of emotionally-valuable content additional textbooks and manuals were used (Baranova et al., 2011; Biboletova et al., 2008; Thompson, Simmons, 2009).

As for teachers, we involved in the experiment those who were focused on work with emotionally-valuable speech material and expressed a desire to master the methods of implementation of the EVC of the content of foreign-language education, to form students' value orientations, to contribute to the formation of a foreign language learner as a multicultural linguistic personality.

According to the requirement of certainty, among the main characteristics of an educational process that affect the mastery of the content of foreign-language education, variable and objectively non-variable components were identified (Lyakhovitsky, 1981). The group of the latter included:

1) the length of time to achieve the objective of work with each text;

2) the amount of speech material to be learnt;

3) the level of foreign-language education where experimental work is carried out, so that students' age characteristics as the internal conditions for functioning the techniques of working with the texts would be approximately the same;

4) the time for checkout: immediately after the experiment;

5) the procedure of checkout and processing of the obtained data.

The following components were used as variable:

1) the quality of speech material to be learnt in experimental groups. The content of the speech material with which the work was carried out met all the criteria of a text of emotionally-valuable content. Before the experiment, however, speech material and exercises, proposed by the authors of the educational-methoical complex "English in focus", was used (Bykova et al., 2017);

2) means, ways, external conditions (axiological and activity components) as constituent parts of work with speech material.

The second phase of the formative experiment is the *implementation* phase. As it is known, it provides the realization of the ideas, set out in the goal and objectives of the study. After carrying out the experimental lessons, the phases of *assertion* and and *interpretation* began. The third phase of experimental work is devoted to quantitative and qualitative characteristics of the results, their appropriate processing, and the fourth phase is the explanation of the results and proof of their reliability. In the phase of assertion the so-called vertical form of checkout was used (A.N. Shamov), involving the comparison of the indicators of mastering the key competences in the field of foreign-language education and the EVC of its content in by the same students, but at different times: before and after the pilot training (Shamov, 2014).

The results were processed, using a special program, designed for a statistical analysis of quantitative data. For this purpose, measuring the spread of data was applied, based on the difference between each individual result and the average arithmetic rate of the group. This measure of spread is *dispersion*, or average square of deviation σ^2. Dispersion shows how much individual results deviate from the average arithmetic rate in the given selection. The bigger the dispersion, the greater the deviation or spread of the data. Dispersion is counted by the following formula:

$$\sigma^2 = \frac{\sum_{i=1}^{n} (x_i - M)^2}{n} \qquad (2)$$

where σ^2 is dispersion, $\sum(x_i - M)^2$ is an expression that means that for all values of x from the first to the last in this selection, the difference between individual results and the average one is calculated, these differences are squared and summed; n is the selection size.

Furthermore, since the sample in the study was small, *corrected sample dispersion* was calculated to improve the accuracy of the obtained statistical data:

$$\mu_{[x\ (M.B)} = \sqrt{\frac{\sigma^2}{n-1}} \qquad (3)$$

where unlike large samples in the denominator instead of n there is $(n–1)$. In this case not the distribution of the sample average values, but the magnitude of their deviations from the average initial population was calculated (Batrakova, 2016).

However, a more convenient characteristic of variation is the result, derived from dispersion, called *standard deviation*, expressed in the same units as the average arithmetic. Therefore, in the second stage of statistical processing of the experimental data, the square root from dispersion was we extracted. The result σ is standard deviation. It allows you to say within what range from the average most of the results of the study is.

Finally, with the help of secondary methods of statistical data, processing the regularity and significance of the results of the formative experiment within the statistical error and the absence of the influence of randomness in the data, were justified. Two hypotheses were formulated:

• H_0 – a null hypothesis: the difference in the results of pre- and post-experimental checkouts is due to random reasons;

• H_1 – an alternative hypothesis: the difference in the results of pre- and post-experimental checkouts is determined by the influence of non-random factors, namely the formative experiment.

To compare two data sets, Fisher criterion was used which is calculated by the formula:

$$F_f = \frac{\sigma\ bigger^2}{\sigma smaller^2} \qquad (4)$$

where in the numerator there is a bigger meaning of the selection dispersion (the sum of square deviations), and in the denominator – a less one. The main principle of statistical hypothesis testing was used to conclude the validity of differences between the results. The critical points for F_{cr} are contained in a special table and are the values of k_1 (the top row of the table) and k_2 (the left column of the table) (Tables...). $k_1 = n_1 - 1$ for the first selection (that is, for the one whose variance is bigger), and $k_2 = n_2 - 1$ for the second selection where n is the number of data in the selection. The null hypothesis is rejected at the level of 5 % if the actual value F_f exceeds or is equal to the critical (standard) value F_{cr} at the level of 5 %. In this case the hypothesis H_1 is accepted.

The study was conducted from 2015 to 2018 and included several stages. At the first stage (2015) the task was to determine the methodological and theoretical bases for the formulation of the research problem. The logic was determined, the investigation methods were specified.

At the second stage (2016) it was necessary to clarify the research program, the formulation of its goals and objectives, to present the concept of a foreign-language text of emotionally-valuable content; to justify the choice of the type of texts to be included in the model of the EVC of the content of primary foreign-language education and to choose an adequate technique of working with them as a model unit of a training impact (the technological level of the concept).

At the third stage (2017) the invariant of the basic model of the EVC of foreign-language education, adapted to the conditions of a junior level in a secondary school, was designed and tested.

The fourth and final stage (2018) was devoted to the systematization of the results and clarification of certain positions of the study, styling its materials and their preparation for publication.

3. Results

3.1. Foreign-language text of emotionally-valuable contents

A foreign-language text of emotionally-valuable contents is a coherent foreign-language speech micro- or macro-utterance that reflects the spiritual experience of mankind and guarantees the implementation of the EVC of the content of foreign-language education.

A foreign-language text of emotionally-valuable contents provides:

● the reflection of the highest humanistic values that have developed the history of human life (man, happiness, society, nature);

● the representation in the content of the desired emotionally-volitional and emotionally-evaluative relations of students to the world, to each other, to reality, to what they are doing in the process of mastering a foreign-language culture;

● taking into account the level of schoolchildren's multicultural and bilingual development, correspondence of the text contents to students' cognitive and communicative needs and opportunities, their life experience and background knowledge;

● the description of objective socio-cultural reality; the introduction of students to the lives of people, belonging to different social strata, races, minorities; learning the identity and originality of representatives of different communities; the vision of the world by a native speaker of another language, including the idea of the world through the prism of the culture of their country and understanding the uniqueness of their own cultural values in the context of global processes;

● the shift of emphasis from the formation of narrowly subject skills and abilities to their integration with other subject and meta-subject skills for a complex spiritual and intellectual development of a personality.

3.2. Argumentation for the selection of the type of texts to include in the model of the emotionally-valuable component of the content of primary school foreign-language education

At the junior level, covering grades 2–4, we intend to consider texts for teaching foreign-language speaking. The selection of the type of texts is due to the fact that a primary school age, according to researchers (Nikitenko, 2010; 2011; Rogova, 1988; and Son Van Huynh et al., 2018), is the most favourable for mastering this type of foreign-language speech activities when the flexibility of the speech apparatus and schoolchildren's simulation abilities for oral verbal communication in a foreign language are actively developing.

3.3. Techniques of working with texts of emotionally-valuable contents

The content and procedural aspects of education are closely connected, and the EVC as a component of social experience and the content of foreign-language education in the aggregate of motives, needs, interests, value orientations, etc. invariably encourages students to work.

Therefore, for mastering this component by a student it is necessary from a methodological point of view not only to have a foreign text that has a certain set of indicators of emotional value, but also a set of adequate techniques of working with it.

Applying the comparative method, in characterizing the concept of a techmique the ideas of E.I. Passov were used. He differentiates two levels of the term – "a technique-concept" (a theoretical level of the notion) and "a technique-act" (a technological level), giving the latter purposefulness (Passov, 2006).

We agree with Z.N. Nikitenko that there are a of challenges of working with primary schoolchildren: lack of differentiation of moral concepts, their desire to identify only their external characteristics, situational ethical actions, failure of speech and social experience. To overcome these difficulties successfully a teacher should strengthen an upbringing component of foreign-language education in elementary school in close unity with the development of students' cognitive and verbal abilities (Nikitenko, 2010). In the context of teaching foreign-language speaking this can be achieved through a properly chosen *technique of working with a foreign-language "spoken" text of emotionally-valuable contents*.

Based on the above, under *the technique of mastering the EVC of the content of foreign-language education* a unit of an educational process is understood, integrating specific conditions, spiritual, material and operational means of working with a text of emotionally-valuable contents, as well as ways of their use. Having an idea of the nature of a technique, a teacher can choose one, adequate to achieving a goal in concrete conditions.

3.4. The invariant of the basic model of the emotionally-valuable component of foreign-language education, adapted to the conditions of a junior level in a secondary school

In this part of the article the model of the EVC of the content of primary school foreign-language education – the invariant of the basic model, adapted to the conditions of a junior level in a secondary school will be introduced (Figure 1). Let us describe it.

● The conceptual block of the model includes a number of leading approaches that have an impact on modernization of the content of foreign language education; principles of selection of the content of foreign-language education; specific criteria for sampling foreign-language micro- and macro-texts, reflecting the content of this component.

● At the content-organizational level of designing the model certain principles and criteria ensure the selection process of the EVC content:

a) the general didactic principles of conformity of the content of education in all its components and at all levels of construction to the requirements of the development of the society, science, culture and personality (the core of the system); the unity of the content and procedural aspects of teaching; the unanimity of its educational, developmental and educational functions; variability and a problematical character;

b) the specific principles of emotionally-valuable significance of speech material, dialogue of cultures, cross-culture, communication, authenticity;

c) the criteria of integral reflection of the tasks of an individual's harmonious development and the formation of his/her basic culture; its scientific and practical significance; the compliance of the complexity of the content with students' educational opportunities; taking into account an international experience of designing the content of education.

● Based on the essence of a technique and its components, an adequate one was selected for the junior level of secondary school education, including material and operational means; ways of working with texts of emotionally-valuable contents in support of the corresponding external and internal conditions. This is the basis for functioning of the operational-procedural block of the model of the EVC, modified for a primary school.

Blocks (subcomponents)	Structure and content of blocks
Conceptual	**Approaches:** systemic-structural, organizational-functional, personal-activity, culturological, axiological, competence, intercultural, communicative **The principles of selection of the EVC content** **General didactic:** • The conformity of the content of education in all its components and at all levels of construction to the requirements of the development of society, science, culture and personality (the core of the system) • The unity of the content and procedural aspects of teaching • The unanimity of its educational, developmental and educational functions of education • Variability • Problematical character **Specific:** • Emotionally-valuable significance of speech material • Dialogue of cultures, • Cross-culture • Communication, • Authenticity **The criteria of selection of micro- and macrotexts** • The integral reflection of the tasks of an individual's harmonious development and the formation of his/her basic culture in the content; • Scientific and practical significance • The compliance of the complexity of the content with students' educational opportunities • Taking into account an international experience of designing the content of education
Content-organizational	EVC Valuable, emotional, volitional subcomponents personal UEA The requirements to texts of the emotionally-valuable The accordance of the text library for primary school to the requirements to texts of the emotionally-valuable contents
Operational-procedural	**The technique of working with to texts of the emotionally-valuable contents** **Means:** • material means of working with educational texts for teaching speaking • operational means of working with educational texts for teaching speaking **Ways** of working with educational texts for teaching speaking

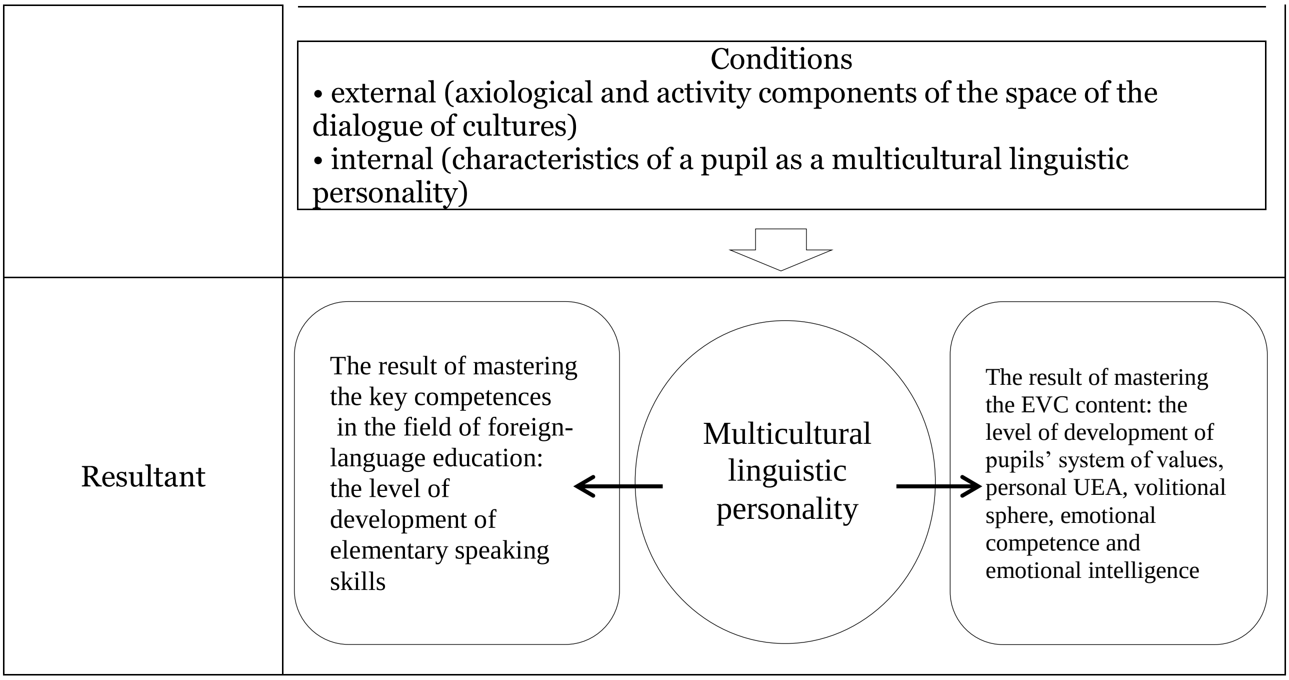


Fig. 1. The model of the emotionally-valuable component of the content of foreign language education for the junior level (grades 2–4)

● At the level of the resultant block the results of mastering the "intellectual" components and the EVC of the content of foreign-language education by primary schoolchildren are presented. In the first case, it is the level of development of pupils' elementary communicative skills in the field of speaking; in the second – the level of development of their system of national and universal values, personal UEA, volitional sphere, emotional competence and emotional intelligence. Their characteristics are planned to be given in the course of experimental work on the implementation of the model of the EVC of the content of foreign-language education in a primary school.

3.5. The results of experimental work on testing the invariant of the model of emotionally-valuable component of the content of primary foreign-language education

Here are examples of MCG, compiled from the standpoint of a student as a multicultural linguistic personality's development on the results of the input (Table 2) and final control (Table 3*). Figure 2 illustrates the dynamics of mastering the key competencies and the sub-components of the EVC of the content of foreign-language by primary schoolchildren.

The main statistical characteristics of the level of students' skills and habits within the framework of the key competences in the field of foreign-language education are presented in Table 4, and the level of proficiency within the EVC of the content of foreign-language education – in Table 5.

Table 6 shows the dynamics of mastering the key competences in the field of foreign-language education and the sub-components of the EVC of its content by the pupils of experimental groups.

Table 7 contains information on changes in the indicators of proficiency in the sphere of the key competencies in the field of foreign language-education and the sub-components of the EVC by different pupils of the experimental groups.

* Limited by the volume of the article, we show the examples of the MCG only for the pupils of grade 3 "a" of Kirov lyceum of natural sciences.

Table 2. The methodical characteristic of the pupils of grade 3 "a" of Kirov lyceum of natural sciences from the standpoint of the development of a multicultural linguistic personality' qualities by the results of entrance control

Pupils' codes	Traits of a multicultural linguistic personality					
	The level of key competences in the field of foreign-language education	The level of development of the system of the nationwide and universal values	The level of development of personal UEA	The level of development of volitional sphere	The level of development of emotional competence and emotional intelligence	**of mastering the EVC of the content of foreign-language**
Measuring units	**Indicators of R_s**	P o i n t s				
1) KLNS3a1*	**0,7 (low)**	3,2 (middle)	8 (middle)	21 (high)	6 (high)	**38,2 (high)**
2) KLNS3a2	**0,6 (low)**	2,1 (low)	6 (middle)	8 (middle)	3 (low)	**19,1 (middle)**
3) KLNS3a3	**0,5 (low)**	3,5 (middle)	7 (middle)	7 (middle)	4 (middle)	**21,5 (middle)**
4) KLNS3a4	**0,2 (low)**	1,7 (low)	8 (middle)	8 (middle)	3 (low)	**20,7 (middle)**
5) KLNS3a5	**0,8 (middle)**	3,2 (middleй)	8 (middle)	17 (high)	4 (middle)	**32,2 (high)**
6) KLNS3a6	**0,5 (low)**	2,8 (middle)	10 (high)	15 (high)	4 (middle)	**31,8 (high)**
7) KLNS3a7	**0,4 (low)**	2,7 (middle)	7 (middle)	14 (high)	2 (low)	**25,7 (middle)**
8) KLNS3a8	**0,7 (low)**	2,9 (middle)	8 (middle)	19 (high)	4 (middle)	**33,9 (high)**
9) KLNS3a9	**0,6 (low)**	2,1 (low)	9 (high)	12 (high)	3 (low)	**26,1 (middle)**
10) KLNS3a10	**0,2 (low)**	2,3 (low)	8 (middle)	19 (high)	4 (middle)	**33,3 (high)**
11) KLNS3a11	**0,5 (low)**	2,3 (low)	8 (middle)	13 (high)	4 (middle)	**27,3 (middle)**

* The pupils' personal data were encrypted as follows: KLNS is the abbreviation of the school's name (Kirov lyceum of natural sciences); 3a is a pupil's grade; 1 is the position of a pupil in the group's list.

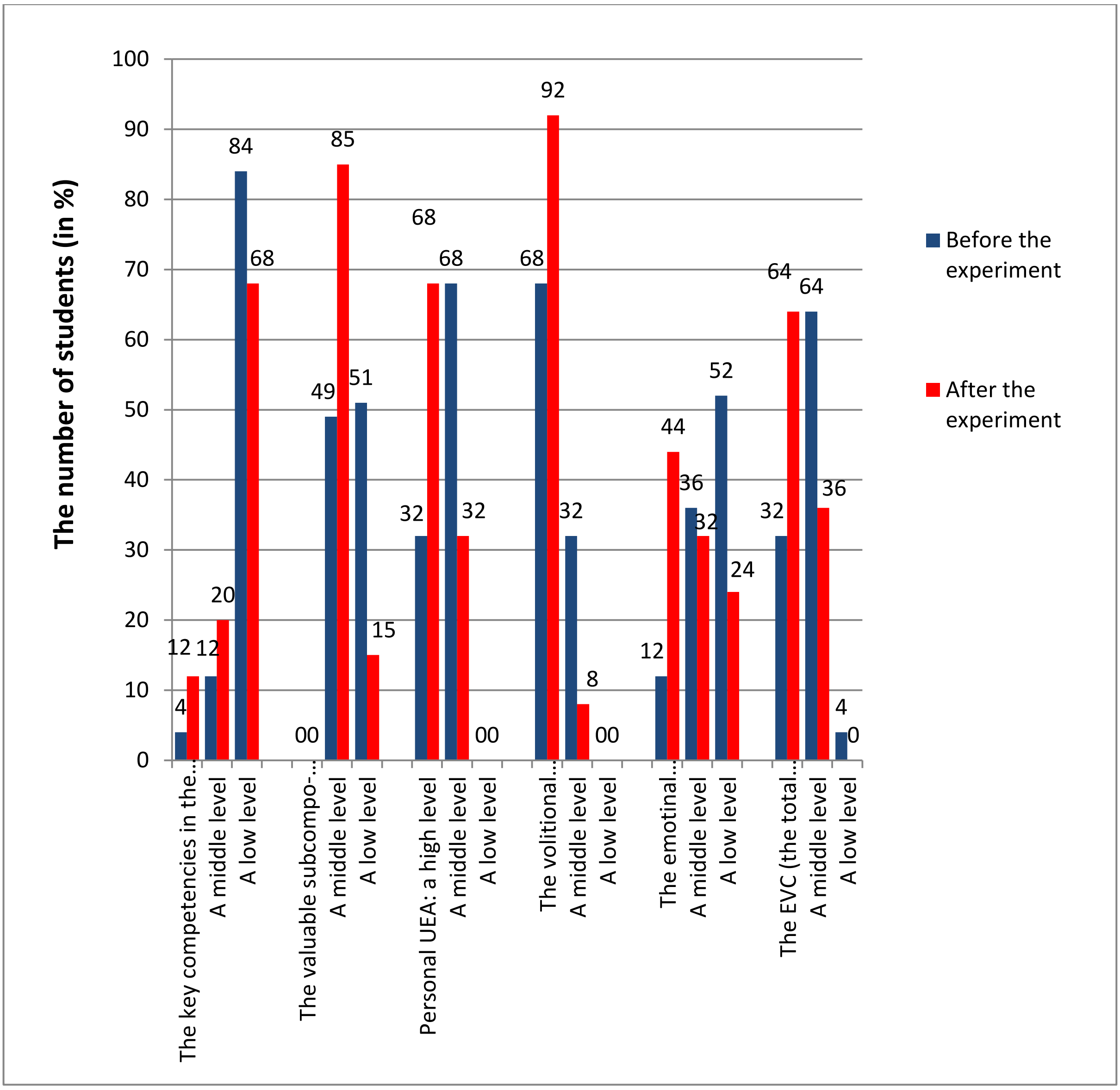
12) KLNS3a12	**0,6 (low)**	2,5 (middle)	8 (middle)	9 (middle)	6 (high)	**25,5 (middle)**
13) KLNS3a13	**0,6 (low)**	2,7 (middle)	8 (middle)	6 (middle)	0 (low)	**16,7 (low)**

Table 3. The methodical characteristic of the pupils of grade 3 "a" of Kirov lyceum of natural sciences from the standpoint of the development of a multicultural linguistic personality' qualities by the results of final control

Pupils' codes	**Traits of a multicultural linguistic personality**					
	The level of key competences in the field of foreign-language education	The level of development of the system of nationwide and universal values	The level of development of personal UEA	The level of development of volitional sphere	The level of development of emotional competence and emotional intelligence	**The total result of mastering the EVC of the content of foreign-language education**
Measuring units	**Indicators of R_s**	Points				
1) KLNS3a1*	**0,75 (low)**	3,3 (middle)	9 (high)	21 (high)	6 (high)	**39,3 (high)**
2) KLNS3a2	**0,7 (low)**	2,3 (low)	8 (middle)	15 (high)	3 (low)	**28,3 (middle)**
3) KLNS3a3	**0,6 (low)**	3,8 (middle)	9 (high)	9 (middle)	5 (high)	**26,8 (middle)**
4) KLNS3a4	**0,55 (low)**	2,5 (middle)	9 (high)	14 (high)	3 (low)	**28,5 (middle)**
5) KLNS3a5	**0,85 (middle)**	3,6 (middle)	8 (middle)	19 (high)	5 (high)	**35,6 (high)**
6) KLNS3a6	**0,9 (high)**	2,8 (middle)	10 (high)	14 (high)	4 (middle)	**30,8 (middle)**
7) KLNS3a7	**0,55 (low)**	2,9 (middle)	10 (high)	16 (high)	3 (low)	**31,9 (high)**

* The pupils' personal data were encrypted as follows: KLNS is the abbreviation of the school's name (Kirov lyceum of natural sciences); 3a is a pupil's grade; 1 is the position of a pupil in the group's list.

8) KLNS3a8	**0,8 (middle)**	3,4 (middle)	10 (high)	19 (high)	4 (middle)	**36,4 (high)**
9) KLNS3a9	**0,65 (low)**	2,4 (low)	11 (high)	13 (high)	4 (middle)	**30,4 (middle)**
10) KLNS3a10	**0,5 (low)**	3,3 (middle)	9 (high)	21 (high)	5 (high)	**38,3 (high)**
11) KLNS3a11	**0,6 (low)**	2,5 (middle)	8 (middle)	19 (high)	5 (high)	**34,5 (high)**
12) KLNS3a12	**0,7 (low)**	2,9 (middle)	10 (high)	16 (high)	6 (high)	**34,9 (high)**
13) KLNS3a13	**0,7 (low)**	3 (middle)	8 (middle)	23 (high)	4 (middle)	**38 (high)**



	Before the experiment	After the experiment
The key competencies in the field of foreign-language education: a high level	4	12
A middle level	12	20
A low level	84	68
The valuable subcomponent: a high level	0	0
A middle level	49	85
A low level	51	15
Personal UEA: a high level	32	68
A middle level	68	32
A low level	0	0
The volitional subcomponent: a high level	68	92
A middle level	32	8
A low level	0	0
The emotinal subcomponent: a high level	12	44
A middle level	36	32
A low level	52	24
The EVC (the total indicator): a high level	32	64
A middle level	64	36
A low level	4	0

Fig. 2. The dynamics of mastering the key competencies and sub-components of the emotionally-valuable component of the content of foreign-language education for primary schoolchildren

Table 4. The main statistical characteristics of the level of mastering the key competencies in the field of foreign-language education by primary schoolchildren

The level of school foreign-language education	Characteristics	Before the experiment	After the experiment
		Indicators of R_s	
Junior	The average value	0,55	0,7
	The minimum value	0,2	0,5
	The maximum value	0,9	0,95
	Standard deviation	0,18	0,13
	The sum of square deviations of data points from the average value	0,81	0,4

	Corrected sample dispersion	0,04	0,03
	Fisher criterion	F_f=2 F_{cr}=1 (<2)	

Table 5. The main statistical characteristics of the level of mastering the emotionally-valuable component of the content of foreign-language education by primary schoolchildren

The level of school foreign-language education	Characteristics	Before the experiment	After the experiment
		Points	
Junior	The average value	28,1	32
	The minimum value	16,7	26,8
	The maximum value	40,8	41,9
	Standard deviation	5,9	4,3
	The sum of square deviations of data points from the average value	859,4	454,1
	Corrected sample dispersion	1,22	0,89
	Fisher criterion	F_f=1,89 F_{cr}=1 (<1,89)	

Table 6. The dynamics of mastering the key competences in the field of foreign-language education and the sub-components of its emotionally-valuable component by the pupils of experimental groups

The indicators of mastering the component structure of the content of foreign-language education												
The level of mastering	**The key competences in the field of foreign-language education**		The EVC									
			The valuable subcomponent		Personal UEA		The volitional subcomponent		The emotional subcomponent		**The total indicators**	
	Before the experiment	**After the experiment**	Before the experiment	After the experiment	Before the experiment	After the experiment	Before the experiment	After the experiment	Before the experiment	After the experiment	**Before the experiment**	**After the experiment**
The number of pupils: 25												
High	**1**	**3**	–	–	8	17	17	23	3	11	**32**	**16**

Middle	**3**	**5**	13	21	17	8	8	2	9	8	**64**	**9**
Low	**21**	**17**	12	4	–	–	–	–	13	6	**4**	**–**

Table 7. The change in indicators of mastering the key competences in the field of foreign-language education and the sub-components of its emotionally-valuable component by the pupils of experimental groups

The change in pupils' indicators	**The key competences in the field of foreign-language education**	The EVC				
		The valuable subcomponent	Personal UEA	The volitional subcomponent	The emotional subcomponent	**The total indicators**
The number of pupils: 25						
The indicators grew up	**24**	24	15	20	15	**24**
The indicators remained the same	**1**	1	9	4	10	**–**
The indicators fell	**–**	–	–	1	–	**1**

4. Discussion

As a result of the study, conducted in the period from 2015 to 2018, all its tasks were solved.

First, the author's definition of a foreign-language text of emotionally-valuable contents is presented. It meets the general didactic and specific principles, as well as the criteria for the selection and organization of the content of education (Babansky, 1989; Lerner, 2002, along with Bim, 2005; Gaskova, Gez, 2004; Passov, 2010; Shamov, 2014 and others).

The first indicator of the emotional value of speech material (the reflection of the highest humanistic values that have developed the history of human life (man, happiness, society, nature)) is associated with the implementation of a valuable sub-component of the content of foreign-language education. The second indicator (the representation in the content of the desired emotionally-volitional and emotionally-evaluative relations of students to the world, to each other, to reality, to what they are doing in the process of mastering a foreign-language culture) reflects primarily the emotional and volitional subcomponents of the EVC.

The indicator "Taking into account the level of schoolchildren's multicultural and bilingual development" is conscript to ensure the compliance of speech material with the needs of students' emotionally-valuable development and communicative-cognitive interests, forming (like all the other indicators) personal UEA. Consequently, the first three indicators are mandatory to ensure that the degree of emotional value of a foreign text is sufficient. If speech material meets all the above requirements, the degree of its emotional value can be considered as high.

Secondly, texts of emotionally-valuable contents for teaching speaking as an oral productive form of foreign-language speech activities, chosen for the inclusion in the model of the EVC of the content of primary school foreign-language education, are important carriers of a foreign-language culture. In accordance with the program requirements, they teach students:

• to mobilize significant emotions for an educational process;
• communication techniques;
• speech etiquette;
• to make up a story about one's friends and the sphere of their interests and hobbies;
• the ability to be interested in their interlocutors' pastime and hobbies, etc. (Collection..., 2008).

The subsystem of such texts is designed to provide the possibility for the EVC to function at any point of teaching speaking, emphasizing the primacy of the moral component of foreign-language education.

Third, if the contents of emotionally-valuable texts-samples involve the description of the socio-cultural reality in which a student "absorbs" the highest humanistic values of a human life and acquires the experience of emotionally-volitional and emotionally-evaluative relations, the presented techniques of working with them, according to L.M. Rizayeva's succinct statement, are "conductors", regulators – a mediating link that transfers information from an object (the content components) to the subject (a student), i.e. everything with the help of which the subject comprehends the object (Rizaeva, 2014: 76).

The search for techniques of working with texts of emotionally-valuable contents was conducted in reliance on *the principle of domination of techniques, actualizing a humanistic, value-orientation focus of foreign-language education,* proposed by L.V. Pavlova. Such techniques are not only informative and instructive, but also have a valuably-analytical, as well as affective-evaluative, interactive, reflexive-actualizing character. The named principle assumes that the used techniques of work with texts of emotionally-valuable contents are model units of an educational influence which:

– stimulate an emotional experience of cultural values, their critical evaluation;
– provide on their basis the experience of communication and interaction;
– contain elements of self-government and self-organization, responsibility for the results of activities;
– ensure conditions for a practical application of socio-cultural knowledge, skills and manifestations of students' socially-significant qualities in the process of solving communication problems (Pavlova, 2016).

Fourth, the presented model of the EVC of the content of primary foreign-language education is able to function at the junior level of teaching a foreign language, providing the first step in the implementation of the component. It is an invariant of its basic model, presented in our earlier study (Tatarinova, 2014). In particular, it was noted that due to its content-structural invariance, the basic model of research can appear in a new modified form, ready to function at any stage of school foreign-language education.

Fifth, testing of the invariant of the EVC model of the content of primary foreign-language education, namely, the data of Tables 2–7 and the diagram in Figure 1 show that the average group results of mastering by primary school students the key competencies in the field of foreign-language education and the EVC of its content improved after the experimental training and moved to a higher level. This confirms the effectiveness of the presented model and the validity of the conceptual postulates of the paper.

The positive dynamics in mastering not only foreign-language speaking, but also the EVC of the content of foreign-language education by schoolchildren of experimental groups proved the necessity and expediency of inclusion of this component in the system of components of the content of foreign-language education at all levels of education and the prospects for further research in the field of *methodological axiology* (the term by E.I. Passov) (Passov, 2010).

5. Conclusion

The results of testing the model of the EVC of the content of primary school foreign-language education led us to the idea of expediency and necessity of the author's concept of this component as the basis for the introduction of *an axiological (emotionally-valuable*) approach to the practice of an educational process in a foreign language. It is possible through the construction and implementation of invariant models of the component for all levels of teaching a foreign language in a secondary school and assumes its focus on the formation of a student's value system as a socio-cultural reality, necessary for him/her to meet his/her needs. In turn, a value orientation of the content of school foreign-language education contributes to the development of students' emotionally-volitional sphere and the system of personal UEA.

It should be noted that this study has a number of limitations. First, it concerns the accuracy of the results of a small sample which is objectively lower than for a larger sample. However, we tried to use the former with caution, accompanied by an appropriate theoretical and practical justification. Secondly, the pilot training, conducted as a part of the experimental study, was not of an interregional nature, but was conducted only within Kirov Region of the Russian Federation. Expanding the scope of the experiment in the future will provide more complete and accurate data, collected for different regions of the country. Finally, some of the measured variables, in particular, the results of mastering the EVC of the content of foreign-language education by junior pupils are quite subjective and may not reflect a real situation.

Nevertheless, the inclusion of the EVC in the component system of the content of foreign-language education in the context of an axiological (emotionally-valuable) approach is effective only when taking into account the main positions of other approaches, applied in the practice of teaching a foreign language in a modern secondary school. The concept of the EVC of the content of foreign-language education is able to provide a harmonious introduction of a student to life as a multicultural linguistic personality – creative and fully developed.

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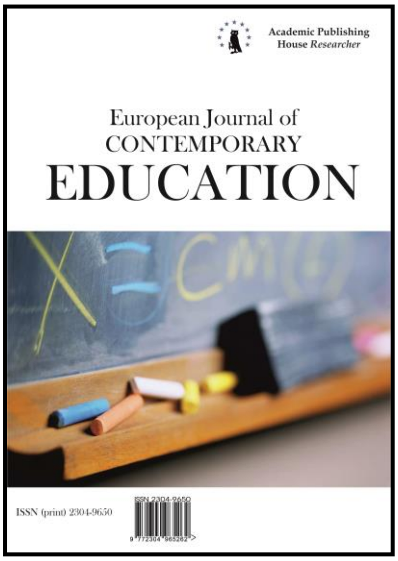

The History of Education

Pedagogical Model of Integrative-Modular Training in Professional Preparation of Students

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Abstract

The present article is aimed to prove that integrative-modular training is one of the conditions for the formation of students' unified vision of the professional world, and to offer a solution to the problem: what is the pedagogical model of integrative-modular training in professional preparation of students. The aim of the article is to describe the features of the pedagogical model of integrative-modular training in professional preparation of students. The review of foreign and russian literature on the subject of the study is done. Research methods include analysis of scientific literature and analysis of learning outcomes. The theoretical, methodological and empirical basis of the study is described. The conceptual apparatus of the pedagogical model of integrative-modular training is specified. The analysis of experimental work of professional preparation of students in the conditions of integrative-modular training is given. Results: the ascertaining, forming and control stages of the experiment within the professional training of students are described. The content of each component of the pedagogical model of integrative-modular training of students is revealed. Finally, it is concluded that the developed pedagogical model of integrative-modular training has a positive impact on the professional training of students, in accordance with the indicators of their professional skills formation.

Keywords: model of training, integrative-modular training, professional preparation of students, higher education.

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1. Introduction

The topicality of the presented research is caused by the fact that the pedagogical model of teaching students is considered as a means of professional preparation of students, indicators of which are general cultural, general professional and specific professional types of competence. On the other hand, the modern education system should correspond to the modern pace of development of scientific, technical and technological components of the society, the rate of increase in the amount of information that a modern person analyzes in professional activities, trends in the integration of the world professional community. Under these conditions, the pedagogical model of integrative-modular training is designed to prepare students to solve problems of this kind. The social order of the society to the modern system of higher education is the order to provide students with progressive professional knowledge and the formation of the future specialist's systematic and complete worldview, the system of professional competencies, including knowledge and skills in a particular professional activity. One of the means of implementation of this order is integrative-modular training.

2. Literature Review

The theory and methodology of professional education involves the use of not only traditional teaching technologies (reduced to illustrative and explanatory way of teaching), but also the active use of innovative technologies. One of these technologies is integrative-modular training, which is one of the ways to build a model of the educational process, the basis of which are completed independent units of information, students' self – preparation for the lesson, parity subject-subject relations between the teacher and the student.

Questions of construction and application of the model of training are studied by many Russian scientists. For example, V.V. Guzeev (2001) develops the theory and practice of integrated educational technologies. I.A. Akulenko (2013) and A.N. Dahin (2002) works on the issues of the essence and effectiveness of pedagogical modeling. The result of their research is the consideration of the modeling process as a general scientific method. In pedagogy, the model is understood as a graphical representation of the process of formation or/and development, for example, professional competencies, and is a system that reflects the process of pedagogical research. One of the main requirements to the model of education is its accordance with the real pedagogical process on the properties and parameters that are studied, as well as the possibility of obtaining new knowledge about the pedagogical process. The problem of constructing pedagogical models is studied by such scholars as A.N. Dakhin (2001), V.D. Lobashev (2006), E.F. Nasyrova (2010) and others. Analysis of their works leads to the conclusion that the concept of "teaching model" is considered in two ways in the scientific and pedagogical literature. Some researchers, for example, An. Dakhin (2001) define this concept somewhat narrowly as a specific example of a multifactorial pedagogical process, created in a special symbolic form, the direct analysis of which gives new knowledge about the studied pedagogical process. Other scientists (Nasyrova, 2010 and others) define the concept of the model more broadly, and present it as a reflection of the parameters of the studied pedagogical process in a purposely created model, which is called the pedagogical model. In this case there are three levels of pedagogical modeling: methodological, theoretical and pedagogical. In accordance with this, there are three groups of pedagogical models: conceptual, didactic and methodical.

The research work by M. Navarro et al. (2016) presents a pedagogical model, describes an integrative training module which helps teachers of the engineering faculty to overcome the problems in the development and implementation of interdisciplinary training programs. Interdisciplinary (integrative) courses in engineering education allow students to critically evaluate knowledge (Orillion, 2009), analyze the correlation of technical, social and human sciences. The work of K. Green and P. Hutchings (2018) is devoted to the development of more effective integrative tasks that contribute to the continuous improvement of learning outcomes of university students. The article by Z.V. Shilova and T.V. Sibgatullina (2017) provides a pedagogical model of teaching University biology students taking into account the professional and applied orientation of training. Ana-Elena Guerrero-Roldán and Ingrid Noguera (2018) proposed a pedagogical model, corresponding with professional competencies and learning activities of students.

The analysis of scientific and methodical works of such scientists as S.N. Goricheva (2016), E.I. Ismagilova (2009) and P.A. Yucyavichene (1989) reveals that integrative and modular training can be considered as a means of integrating knowledge in the process of obtaining new knowledge, cognitive activity, allowing the professional to adapt to the changed conditions, to think critically and generate new ideas. E.F. Nasyrova (2010) in her works shows that integrative-modular training provides individualization of the following components of training: content, pace of learning, independence, types of control and self-control. In addition, these scientists defined the purpose of interactive-modular training: the creation of conditions for the formation of students' independence through the implementation of the main components: the integrated curriculum, the modular program and the training module.

3. Materials and Methods

The following methods were used in the research: theoretical (analysis of literature on the problem under study, systemic analysis, classification, modelling); empirical (pedagogical observation, survey); statistical (statistical observation, methods of statistical analysis). Research methods are based on the study and analysis of the results of pedagogical and scientific and methodical research results of foreign and Russian authors on the problem of improving the quality of teaching methods with the help of integrative-modular training in professional preparation of students.

The theoretical and methodological basis of this study are: the principles of the theory of systematic understanding of pedagogical processes (Kraevsky, Khutorskoy, 2007 and others); the principles of the competence approach in professional education (Abramova, 2016, 2017; Polat, Bukharkina, 2009; Shilova, 2011 and others); the principles of the technologization theory of the pedagogical process (Bespalko, 2009 and others).

General theoretical and special theoretical methods of research allow us to clarify the conceptual apparatus of the pedagogical model of integrative-modular training. In the present study, the term "pedagogical model" is understood as a graphical representation of the formation process of students' professional efficiency in accordance with the professional society's order. The concept of interactive-modular training" includes an integrated curriculum, modular programs of professional disciplines and subject modules. The process of professional preparation of students in this study is understood as the formation process of general cultural, general professional and specific professional competences of students.

We present the content of the pedagogical model of integrative-modular training in professional preparation of students, which is focused on the implementation of the society's social order for initiative and educated professionals. In the generalized form the pedagogical model of integrative-modular training of students is given in Figure 1.

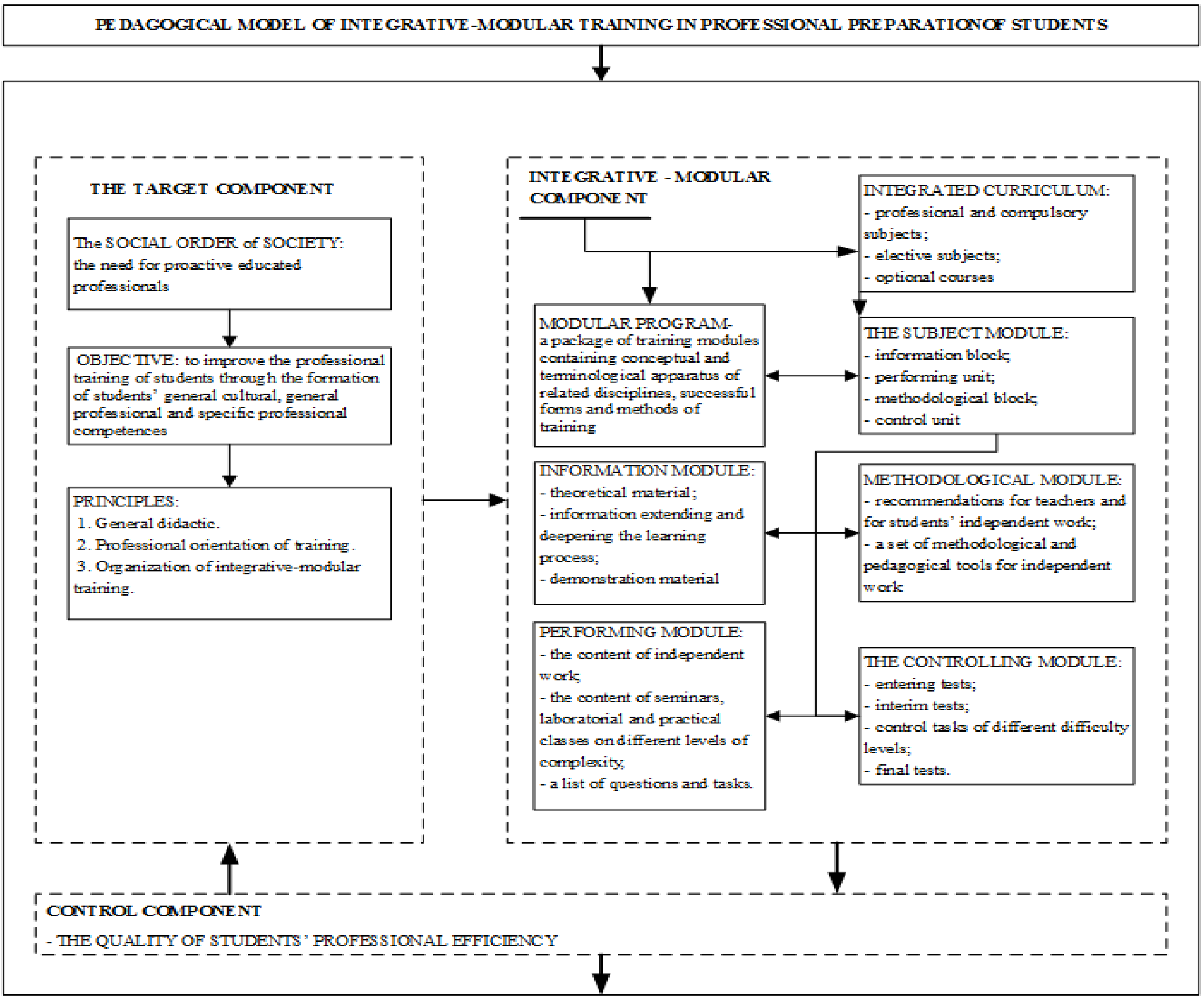

Fig. 1. Model of integrative-modular teaching in professional training of students

Pedagogical features of the model of integrative-modular training in professional preparation of students consist in adaptation of the integrative-modular training model content to professional training for a specific field. In this study, the content corresponds to the professional training in the field of Applied mathematics and Computer Studies.

Social order of the society determines the target component of the model (social order, purpose, principles). The purpose is formulated in accordance with the content of indicators of students' professional training formation, namely: improvement of students' professional competence level. The content of indicators of students' professional training formation is as follows:

I. General cultural – the ability to apply the foundations of philosophical knowledge to the formation of ideological positions, legal and economic knowledge in professional life; communication in oral and written forms for the organization of interpersonal and intercultural interaction and teamwork;

II. General professional – the ability to use basic knowledge of mathematical and natural sciences, to acquire new scientific and professional knowledge, to develop algorithmic and software solutions in the field of system and applied programming, to solve standard problems of professional activity;

III. Specific professional competencies are divided according to the types of activities: research one, design one, production and technological one, organizational and management one.

The theoretical material of the information block is organized in the form of lectures revising the theory of the above mentioned sections of disciplines. In the same block the information deepening the educational process and demonstration materials are provided. The methodical block is presented in the form of methodical recommendations in accordance with the content described above. The performing unit is organized in the form of laboratory and practical training on the content mentioned above. The control unit is in-between and final tests, in accordance with the score-rating system of the University. The principles of professional efficiency formation are selected in accordance with the purpose and characteristics of competencies, namely: general didactic (scientific, systematic, etc.) one, professional orientation of training principle, integrative-modular training principle.

These three parts of the objective component of the model determine the content of the integrative-modular component, which consists of three main modules:

- integrative curriculum, including professional and compulsory subjects (26 subjects of the basic part and 15 subjects of the variable part); elective subjects include 13 pairs of subjects; three optionals;

- modular program, including a package of training modules containing conceptual and terminological thesaurus of related disciplines and successive forms and means of training. As an example of a modular program it is possible to take the module "Theoretical Foundations of Computer Modeling", the purpose of which is to systematize knowledge in the field of computer modeling, to adapt previously acquired knowledge in computer modeling, to implement succession between the disciplines of the basic and variable parts. The module includes information from the disciplines: "Introduction to Applied Mathematics", "Ordinary Differential Equations", "Mathematical Models in Economics", "Modeling of Computer Systems", "Mathematical Logic and Theory of Algorithms", "Modeling Systems and Computer Simulation", "Theory of Experiment Planning", "Computer Probabilistic Statistical Modeling»;

- subject module consists of four units: information, technical, methodical and controlling. The content of each block is given in accordance with the modular program "Theoretical Foundations of Computer Modeling". The information block contains: theoretical material of the sections "Linear Differential Equations of the n-th Order with Constant Coefficients, the Structure of their General solution", "Matrix Method of Integration of Linear Systems of Differential Equations" of the discipline "Ordinary Differential Equations"; sections "Basic Concepts of the Algorithm Theory", "Description and Examples of Primitive Recursive Functions", "Partially-Recursive Functions" of the discipline" Mathematical Logic and Algorithm Theory»; sections "Mathematical Processing of Experimental Results", "Regression Analysis of Experimental Data", "Factor Plans of Experiments" of the discipline "Experiment Planning Theory"; sections "Computer Modeling Technology and its Stages", "Simulation Modelling" of the discipline" Computer Probabilistic Statistical Modeling", information, deepening the educational process from the sections "Functions in the Economic Processes Modeling", "Linear models of Economics", "Network modeling" of the disciplines "Mathematical Models in Economics»; sections "Fundamentals of Modeling Information Systems", "Approaches to modeling information systems" of the discipline "Modeling information systems". The demonstration material is taken from the sections "Problems of Applied Mathematics and Computer Studies", "Problems of Mathematical Support of Computer Systems", "Problems of Probability Theory and Mathematical Statistics" of the discipline "Introduction to Applied Mathematics" and from the sections "Mathematical modeling of Objects and Systems", "Modeling of Random Variables, Processes and Event Flows" of the discipline "Modeling Systems and Machine Simulation". The methodical module contains methodical recommendations for students and teachers on individual and independent work on the highlighted sections of disciplines. The performing block of the module "Theoretical foundations of computer modeling" involves students' independent work on the material of the module on the issues compiled in accordance with the sections of the disciplines that make up the modular program. The content of laboratorial and practical classes has different levels of complexity, in accordance with the rating system of the University. The low level involves the development of basic knowledge of this module, corresponding to the educational standard. The intermediate level contains the tasks that involve the use of the ability to transform basic knowledge into practical professional activity. High level means the solution of non-standard tasks from the professional field, defence of the student's grounds, proof of efficiency of their knowledge application and their practical professional skills. The list of questions and tasks create conditions for the successful passage of the control unit of the subject module of the integral-modular component. On the basis of the problems of the relevant sections of disciplines the entering test is created. Basing on the list of questions and tasks of the module, in-between and final tests are compiled. It should be noted that the University rating system creates favorable conditions for students to perform control tasks of different levels of complexity. Students are interested in obtaining the maximum number of points for control activities, so they strive to show their erudition, creativity, professional efficiency of knowledge application.

After the implementation of the integral-modular component, it is necessary to carry out the control component of the pedagogical model of integral-modular training in the professional preparation of students. The realization of this component is based on determining the degree of quality of students' professional efficiency. This is revealed not only in classroom knowledge, possession of professional skills, but also in their application in professional activities during probations: obtaining primary professional skills, traineeships, obtaining real professional skills and experience of professional activity. If the quality of formation of students' professional efficiency satisfies the professional community, which is reflected in the students' characteristics after their probations, the conclusion is made about the effectiveness of the pedagogical model of integrative-modular training of students. If there are any shortcomings in the professional efficiency of students, it is necessary to return to the objective component of the model, adjust it and integrative-modular component, and again check the quality of the formation of professional efficiency of students.

Empirical research methods have allowed to implement, analyze and make a conclusion about the effectiveness of the pedagogical model of integrative-modular training in professional training of students. Experimental work was organized and carried out for two years with students doing Applied mathematics and Computer Technologies.

The following methods of statistical analysis were used in the study: sampling method, comparison method (nonparametric criterion for independent samples: Chi-square). The study sample consisted of the third- and fourth-year students of the study field 01.03.02 Applied mathematics and Computer Studies, with a total of 48 people from the Federal State Budget Educational Institution of Higher Education (FSBEI HE)" Vyatka state University» (of these, 28 people were in the control group, a group of 20 people were in the 1st experimental group) and 20 people from Federal State Budget Educational Institution of Higher Education (FSBEI HE) "Perm State National Research University" (this group of 20 people was part of the 2nd experimental group). The use of statistical analysis methods allows to determine the students' professional efficiency formation level and in accordance with it to conclude about the effectiveness of the presented model of integrative modular training.

4. Results

4.1. Ascertaining stage of the experiment

The experimental work was carried out in FSBEI HE "Vyatka state University" and FSBEI HE "Perm State National Research University" (68 students in total). The study ran from September 2016 to June 2018. The aim of the experimental work was: to increase the level of indicators the students' professional efficiency formation level: general cultural, general professional, specific professional competencies, the content of which is described above.

The experimental work had three stages: ascertaining, forming and control ones.

The ascertaining stage of the experiment took place in September 2016, which included projecting of the integrative-modular training model at the University in the framework of students' professional training, the search for opportunities to implement individual components of the model and the questionnaire. The purpose of the ascertaining stage of the experiment was: to identify the initial level of formation of indicators of professional training of students. The forms of the ascertaining stage of the experiment were: testing and analysis of the students' testimonials basing on the results of their probations. On the basis of questions and tasks sections of those subjects that are included in the modular program "Theoretical foundations of computer modeling" a modified set of tasks to identify the initial level of formation of indicators of students' professional efficiency are created (3 tasks for each indicator). The tasks for diagnostic testing are grouped in accordance with the indicators of students' professional training. Upon completion of the test, the initial level of formation of students' professional efficiency in accordance with the indicators and levels of their formation (described above) is revealed. The results evaluation is the same for all methods:

3 points – the student does a non-standard task from the field of professional activity, justifies his position on the effective application of knowledge and skills in practical professional activity;

2 points – the student does a task that involves the use of the ability to transform basic knowledge into practical professional activity;

1 point – the student does the basic task of the module corresponding to the educational standard.

A student can get a maximum of 27 points, the minimum-0 points. According to the levels of formation of students' professional efficiency, the points can be grouped as follows:

Low level – from 0 to 9 points;

Intermediate level – from 10 to 18 points;

High level – from 19 to 27 points.

The results were processed by interpreting the Chi-square indicator, for which all the necessary restrictions were met. EG1 is the first experimental group, consisting of students from FSBEI HE "Vyatka State University". EG2 is the second experimental group, including the students from FSBEI HE "Perm State National Research University" (Table 1).

Table 1. The level of formation of students' professional efficiency of experimental groups before the experiment

Groups	The level of formation of students' professional efficiency						Total
	High		Intermediate		Low		
	total	%	total	%	total	%	
EG1	$Q_{11} = 2$	10	$Q_{12} = 14$	70	$Q_{13} = 4$	20	$n_1 = 20$
EG2	$Q_{21} = 3$	15	$Q_{22} = 12$	60	$Q_{23} = 5$	25	$n_2 = 20$
total	5		26		9		

$$\chi^2_{эмп} = \frac{1}{n_1 \cdot n_2} \cdot \left(\frac{(n_1 \cdot Q_{21} - n_2 \cdot Q_{11})^2}{Q_{11} + Q_{21}} + \frac{(n_1 \cdot Q_{22} - n_2 \cdot Q_{12})^2}{Q_{12} + Q_{22}} + \frac{(n_1 \cdot Q_{23} - n_2 \cdot Q_{13})^2}{Q_{13} + Q_{23}} \right) =$$

$$= \frac{1}{20 \cdot 20} \cdot \left(\frac{(20 \cdot 2 - 20 \cdot 3)^2}{5} + \frac{(20 \cdot 14 - 20 \cdot 12)^2}{26} + \frac{(20 \cdot 4 - 20 \cdot 5)^2}{9} \right) =$$

$$= \frac{20^2}{20^2} \cdot \left(\frac{(-1)^2}{5} + \frac{2^2}{26} + \frac{(-1)^2}{9} \right) = 0,46$$

According to the statistical table of critical values of the criterion $\chi 2$ we have $\chi^2_{crit} = 5{,}99$ for the significance level 0.05 and the degree of freedom $k = 3 - 1 = 2$ (Glass, Stanley, 1976). So, $\chi^2_{emp} < \chi^2_{crit}$, because 0,46 < 5,99, and at the significance level of 0.05 (with a reliability of 95 %), we assume that before the experiment, the students of groups EG1 and EG2 on average had initially the same level of professional efficiency. Therefore, we can combine both groups and further consider them as a single experimental group (EG).

The results of the ascertaining stage of experimental work are presented in table 2 (CG – control group, EG – experimental group) and Figure 2.

Table 2. The initial level of students' professional efficiency formation

Groups	**The level of formation of students' professional efficiency**						Total
	High		Intermediate		Low		
	total	%	total	total	%	total	
CG	$Q_{11} = 1$	8	$Q_{12} = 12$	44	$Q_{13} = 15$	48	$n_1 = 28$
EG	$Q_{21} = 2$	4	$Q_{22} = 19$	48	$Q_{23} = 19$	48	$n_2 = 40$
total	3		31		34		

$$\chi^2_{эмп} = \frac{1}{n_1 \cdot n_2} \cdot \left(\frac{(n_1 \cdot Q_{21} - n_2 \cdot Q_{11})^2}{Q_{11} + Q_{21}} + \frac{(n_1 \cdot Q_{22} - n_2 \cdot Q_{12})^2}{Q_{12} + Q_{22}} + \frac{(n_1 \cdot Q_{23} - n_2 \cdot Q_{13})^2}{Q_{13} + Q_{23}} \right) =$$

$$= \frac{1}{28 \cdot 40} \cdot \left(\frac{(28 \cdot 2 - 40 \cdot 1)^2}{3} + \frac{(28 \cdot 19 - 40 \cdot 12)^2}{31} + \frac{(28 \cdot 19 - 40 \cdot 15)^2}{34} \right) =$$

$$= \frac{1}{1120} \cdot \left(\frac{16^2}{3} + \frac{52^2}{31} + \frac{(-68)^2}{34} \right) = 0,28$$

According to the statistical table of critical values of the Chi-square criterion, we find χ^2_{crit} = 5,99 for the significance level 0.05 and the degree of freedom k = 3 – 1 = 2 (Glass, Stanley, 1976). So, $\chi^2_{emp} < \chi^2_{crit}$, because 0,28 < 5,99, and at the level of significance 0.05 (with reliability of 95 %) we can say that the differences in the levels of formation of students' professional efficiency in the control and experimental groups (CG and EG) at the ascertaining stage of the experiment are not statistically significant, that is, students of KG and EG on average have the same level of formation of professional efficiency.

Let us present the results of the ascertaining stage of the experimental work graphically in Figure 2.

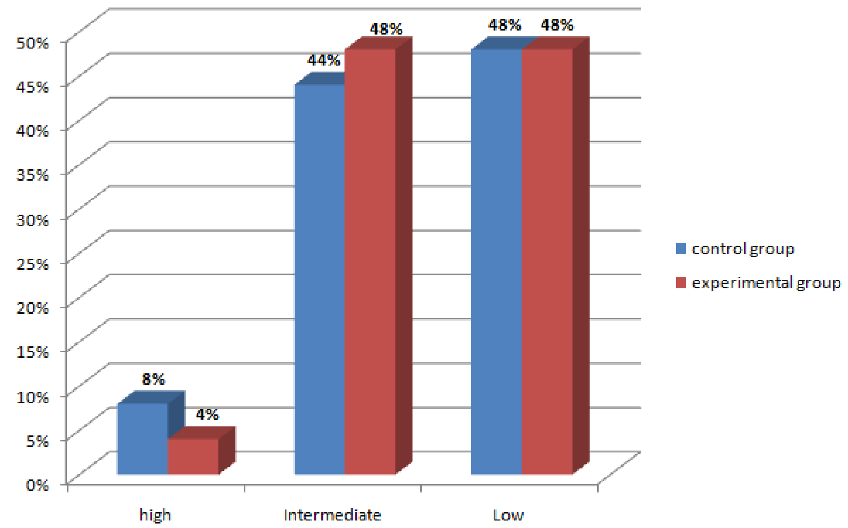

Fig. 2. Initial level of professional efficiency

Analysis of students' testimonials after their probations revealed the employers' wishes to increase the practical orientation of students' professional training.

The result of the ascertaining stage of the experiment was the scientific and pedagogical rationale for the implementation of integrative-modular training in the framework of professional training of University students.

4.2. Forming stage of the experiment

The forming stage of the experiment was performed on the basis of FSBEI HE "Vyatka State University" and FSBEI HE "Perm State National Research University" (68 students in total). The purpose of the forming stage of the experimental work was to identify the effectiveness of the modular program "Theoretical foundations of computer modeling." The subject module of the program was implemented from October 2016 to April 2018.

The information block contains: theoretical material of the sections "Linear Differential Equations of the n-th Order with Constant Coefficients, the Structure of their General solution", "Matrix Method of Integration of Linear Systems of Differential Equations" of the discipline "Ordinary Differential Equations"; sections "Basic Concepts of the Algorithm Theory", "Description and Examples of Primitive Recursive Functions", "Partially-Recursive Functions" of the discipline" Mathematical Logic and Algorithm Theory»; sections "Mathematical Processing of Experimental Results", "Regression Analysis of Experimental Data", "Factor Plans of Experiments" of the discipline "Experiment Planning Theory"; sections "Computer Modeling Technology and its Stages", "Simulation Modelling" of the discipline" Computer Probabilistic Statistical Modeling", information, deepening the educational process from the sections "Functions in the Economic Processes Modeling", "Linear models of Economics", "Network modeling" of the disciplines "Mathematical Models in Economics»; sections "Fundamentals of Modeling Information Systems", "Approaches to modeling information systems" of the discipline "Modeling information systems". The demonstration material is taken from the sections "Problems of Applied Mathematics and Computer Studies", "Problems of Mathematical Support of Computer Systems", "Problems of Probability Theory and Mathematical Statistics" of the discipline "Introduction to Applied Mathematics" and from the sections "Mathematical modeling of Objects and Systems", "Modeling of Random Variables, Processes and Event Flows" of the discipline "Modeling Systems and Machine Simulation". The methodical module contains methodical recommendations for students and teachers on individual and independent work on the highlighted sections of disciplines. The performing block of the module "Theoretical foundations of computer modeling" involves students' independent work on the material of the module on the issues compiled in accordance with the sections of the disciplines that make up the modular program. The content of laboratorial and practical classes has different levels of complexity, in accordance with the rating system of the University. The low level involves the development of basic knowledge of this module, corresponding to the educational standard. The intermediate level contains the tasks that involve the use of the ability to transform basic knowledge into practical professional activity. High level means the solution of non-standard tasks from the professional field, defence of the student's grounds, proof of efficiency of their knowledge application and their practical professional skills. The list of questions and tasks create conditions for the successful passage of the control unit of the subject module of the integral-modular component. On the basis of the problems of the relevant sections of disciplines the entering test is created. Basing on the list of questions and tasks of the module, in-between and final tests are compiled. It should be noted that the University rating system creates favorable conditions for students to perform control tasks of different levels of complexity. Students are interested in obtaining the maximum number of points for control activities, so they strive to show their erudition, creativity, professional efficiency of knowledge application.

4.3. The control stage of the experimental work

The control stage of experimental work was held in May-June 2018 with the students of the control and experimental groups. The purpose of the control stage of experimental work was to identify the final level of indicators of students' professional efficiency. Methods of this stage were testing, analysis of the students' testimonials on the basis of their probations. The study was conducted using the same methods as at the ascertaining stage of the experiment. The results of the control stage of the experimental work are presented in Table 3, Figure 3.

Table 3. The final level of students' professional efficiency formation

Groups	The level of students' professional efficiency formation						Total
	High		Intermediate		Low		
	total	%	total	total	%	total	
CG	$Q_{11} = 6$	20	$Q_{12} = 15$	52	$Q_{13} = 7$	28	$n_1 = 28$
EG	$Q_{21} = 16$	40	$Q_{22} = 22$	56	$Q_{23} = 2$	4	$n_2 = 40$
total	22		37		9		

$$\chi^2_{эмп} = \frac{1}{n_1 \cdot n_2} \cdot \left(\frac{(n_1 \cdot Q_{21} - n_2 \cdot Q_{11})^2}{Q_{11} + Q_{21}} + \frac{(n_1 \cdot Q_{22} - n_2 \cdot Q_{12})^2}{Q_{12} + Q_{22}} + \frac{(n_1 \cdot Q_{23} - n_2 \cdot Q_{13})^2}{Q_{13} + Q_{23}} + \frac{(n_1 \cdot Q_{24} - n_2 \cdot Q_{14})^2}{Q_{14} + Q_{24}} \right) =$$

$$= \frac{1}{28 \cdot 40} \cdot \left(\frac{(28 \cdot 16 - 40 \cdot 6)^2}{22} + \frac{(28 \cdot 22 - 40 \cdot 15)^2}{37} + \frac{(28 \cdot 2 - 40 \cdot 7)^2}{9} \right) =$$

$$= \frac{1}{1120} \cdot \left(\frac{208^2}{22} + \frac{16^2}{37} + \frac{(-224)^2}{9} \right) = 6,74$$

According to the statistical table of critical values of the Chi-square criterion, we find $\chi^2_{crit} = 5{,}99$ for a significance level of 0.05 and degrees of freedom $k = 3 - 1 = 2$ (Glass, Stanley, 1976). Thus, $\chi^2_{emp} > \chi^2_{crit}$, since 6,74 > 5,99, and at the significance level of 0.05 (with a reliability of 95 %) we can say that the differences in the levels of formation of students' professional efficiency in the control and experimental groups (KG and EG) at the ascertaining stage of the experiment are statistically significant, that is, there is an increase in the level of indicators of professional efficiency formation of the students from the experimental group.

The results of the control stage of the experimental work in the control and experimental groups are graphically presented in Figure 3.

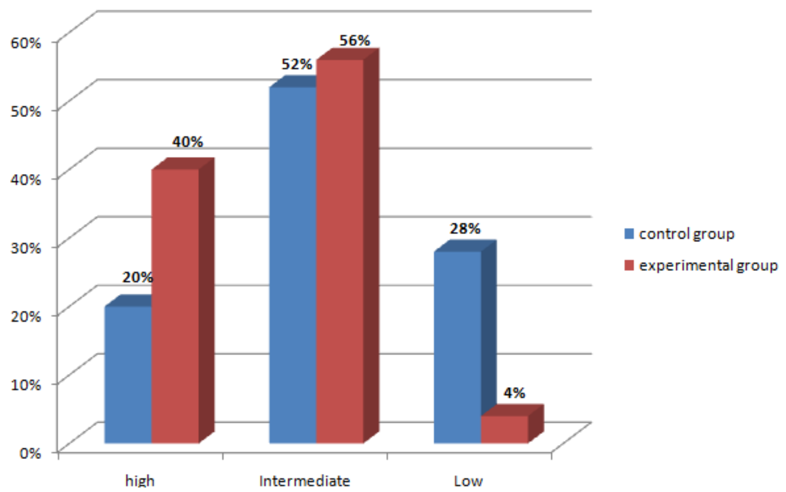

Fig. 3. The final level of formation of students' professional efficiency

Thus, it is possible to talk about the effectiveness of the implementation of the modular program "Theoretical foundations of computer simulation" in the context of integrative and modular training of students, with the aim of raising the level of indicators of formation of their professional efficiency. During the educational process, students form integrative links with other disciplines.

5. Discussion

In accordance with the requirements of higher education standards in Russia, one of the priorities in the educational process is the formation of students' professional efficiency. At the same time, a lot of researchers pay attention to the shortcomings of the traditional method of teaching mathematics to students of higher educational institutions, which does not provide a high quality of mastering mathematical material and the formation of professional competence in students.

To date, the system of vocational education has developed several different approaches to improve the quality of professional training of students. The most promising of them is the integrative-modular approach. It allows on the basis of modular construction of educational process, to integrate educational material, and to come to higher quality level in professional training of students, being guided by the aim to train competitive experts.

Theoretical aspects of integrative-modular training are dealt with in the works by Ismagilova (2009), Nasyrova (2010), Sadovskaya (2005), etc. In her study, Ismagilova (2009) gives a didactic model of professional orientation of teaching mathematics to students studying radio-electronics. The model contains an integrative-modular component, which the author defines as a variable part of the content of mathematical training of students, reflecting the intra – and inter-subject connections of the selected modules in the content of mathematical, general and speciphic disciplines. Ismagilova (2009) proposes to strengthen the professional orientation of teaching mathematics through a system of integrative mathematical courses, the purpose of which is to combine the various content components of mathematical and General engineering disciplines, the formation of students' integrative knowledge and skills in mathematics as a holistic block. Meanwhile, this model does not take into account the aspects of the formation of students' general cultural, general professional and specific professional competences. Nasyrova's research (2010) is devoted to professional training of the technology teacher which is defined as functional and personal readiness of the graduate to implement general cultural and professional competences for the solution of professional and pedagogical tasks. The functional readiness of the technology teacher is a state of the teacher's personality, who considers herself prepared and capable of carrying out professional and pedagogical activity, providing Polytechnic and personal readiness of the school graduate. Personal readiness of the technology teacher is her internal psychological mood to perform professional and pedagogical tasks, the formation of professionally important qualities of the individual. Meanwhile, in contrast to the presented model, Nasyrova's methodical model (2010) does not contain aspects of the development of students' personality professionally significant qualities, the formation of their personal professional potential. One of the effective methods of formation of professionally significant qualities, according to the authors, is the use of personality-oriented technologies in the course of practical training , which is understood as an ordered set of actions, operations and procedures aimed at the development of personality, instrumental in achieving a diagnosed and predictable result in professional and pedagogical situations, forming an integration unity of forms and methods of training in the interaction of the student and the teacher in the activity process. The research by Sadovskaya (2005) is devoted to the issues of professional and pedagogical training of a novice University lecturer-researcher, the formation of his personal professional potential. The work in the formation of students' professional orientation does not use a system of professional and applied problems based on the method of modeling. Meanwhile, we share the point of view of Sadovskaya (2005) that the structure of professional training of students is determined by the synthesis of professional knowledge (epistemological component), value relations (axiological component) and professional skills (praxiological component). The epistemological component of students' professional training is determined by the content of theoretical and practical knowledge, which is based on the study of modern technologies and trends of its development and the acquisition of integrative knowledge. The axiological component of professional training is determined by the value relations, orientations, motives of educational and professional activity. The transformation of oneself, the reassessment of values, the creation of a value scale, which leads the person to a value orientation, in the process of which there is an awareness of the future, valuable for the person, the image of the personality of the future specialist is formed. The model of students' professional training proposed by the authors of the article is a pedagogically conditioned sequence of teaching cycles the curriculum disciplines, having a general orientation of training and development of the system of students' professionally significant qualities, using a system of professional and applied tasks based on the modeling method, and takes into account all the above aspects. Such system on the basis of integrative-modular training represents methodically caused, consecutive, systematic order of the modules of the basic educational program providing integration which are in a certain dependence and make the whole in students' professional training according to the requirements of modern Federal state standards of the higher education. Many researchers, including those mentioned above, pay attention to the shortcomings of the traditional method of teaching mathematics to University students, which does not provide high quality of mastering mathematical material. The proposed pedagogical model of the integrative-modular teaching mathematics in the training of students overcomes the shortcomings of traditional teaching methods. Here we consider it necessary to take into account the professional orientation of students, which is possible, for example, using a system of professional and applied tasks based on the modeling method. In turn, the use of professional and applied tasks increases the motivational and educational components of students' personal development. Thus, the analysis of the scientific works published on this issue allows us to conclude that the theoretical, methodological and practical aspects of the implementation of the methodological system to form University students' professional efficiency in the conditions of vocational training remain insufficiently developed.

6. Conclusion

The data obtained allow us to conclude that pedagogical models in general are both the aim and the means of implementation of activities in methodological modeling. They are characterized by integrity and openness, which creates conditions for their adaptation to a specific field of training and revealing additional functional relationships between the elements of the model. According to the results of the study, we can talk about the effectiveness of the pedagogical model of integrative-modular training in the professional preparation of students in the field of "Applied mathematics and Informatics", which is proved by the activation of their cognitive activity, the development of creative attitude to the profession, independence and development of other professionally significant qualities. The indicators of good professional efficiency of students, which determined the effectiveness of the implementation of the pedagogical model of integrative-modular training in the preparation of students, are as follows:

I. General cultural – the ability to apply the foundations of philosophical knowledge to the formation of ideological positions, legal and economic knowledge in professional life; communication in oral and written forms for the organization of interpersonal and intercultural interaction and teamwork;

II. General professional – the ability to use basic knowledge of mathematical and natural sciences, to acquire new scientific and professional knowledge, to develop algorithmic and software solutions in the field of system and applied programming, to solve standard problems of professional activity;

III. Specific professional competencies are divided according to the types of activities: research one, design one, production and technological one, organizational and management one.

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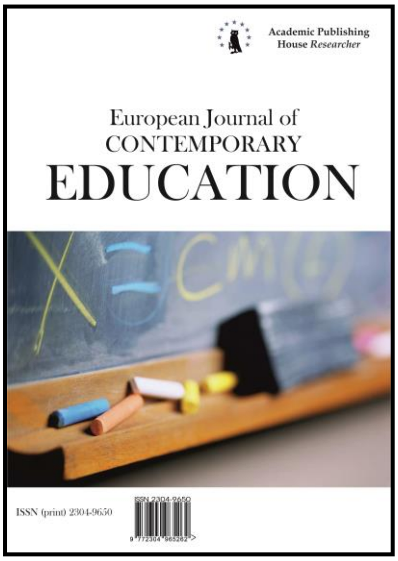

Free Education: Fundamentals of Humanistic Pedagogics (on the example of Activity of the German Public Figures of the second half of XIX – the beginning of the XX centuries of F. Gansberg, L. Gurlitt, G. Sharrelman)

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Abstract

The problem of free education as the direction in reformatory pedagogics of Germany of the second half of XIX – the beginnings of the XX centuries is staticized in this article. The child is the center of pedagogical process according to free education. Historical, system, culturological approaches are main in a research of this problem. They allowed to reveal intrinsic characteristics, features of process of education in Germany of the considered period. The leading ideas of free education it is a pedocentrizm as the organization of pedagogical process. The interests of children, refusal of systematic training and education of children by in advance developed curricula and programs, orientation to free works of the teacher and pupils enter here. The german teachers reformers F. Gansberg, L. Gurlitt, G. Sharrelman, figures of the Bremen school of sciences, founders of the concept of new «free education» (the theory of the personality), considered education the leading means of formation of the humane personality. They considered the personality as the highest value of society. Materials of article can be useful to pedagogical workers, organizers of educational work with the studying youth to acquaintance to life and activity of the famous German teachers and public figures of the second half of XIX – the beginning of the XX centuries.

Keywords: free education, german public figures, second half of XIX – the beginning of the XX centuries, students.

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1. Introduction

Free education is the direction in reformatory pedagogics of Europe of the second half of XIX – the beginnings of the XX centuries. It developed traditions of freedom in training and education of children. The child is the center of pedagogical process according to free education.

The main representatives are Ellen Kay (1849-1926, Sweden); Fritz Gansberg (1871-1950, Germany); Ludwig Gurlitt (1855-1931, Germany); Maria Montessori (1870-1952, Italy).

Leading ideas of free education:

- the principle of a pedocentrizm is the organization of pedagogical process for the benefit of children. The interests of children directly arose in the course of their activity;
- refusal of systematic, systematic training and education of children by in advance developed curricula and programs;
- orientation to free works of the teacher and pupils.

The central ideas of free education are considered by eminent public figures of Germany during the considered period.

2. Materials and methods

System, historical and culturological approaches made methodological base of the publication. They allowed to reveal intrinsic characteristics, regularities and the principles of feature of process of free education in Germany of the considered period. These approaches also prove the theoretical conclusion about expediency of this work.

The principles of systemacity, historicism are the basis for the publication. They helped authors to carry out the analysis of activity of the famous German teachers and public figures of the second half of XIX – the beginning of the XX centuries on a problem of free education of younger generation.

Problem and chronological and comparative methods played a special role. They were used for classification, comparison, the characteristic of various approaches in the description of a problem of free education in Germany of the studied period.

Allocation of relationships of cause and effect, unities of the theory and practice was carried out within modern approaches to a research of the historical and pedagogical phenomena.

The descriptive method and the retrospective analysis of pedagogical experience of education of the German youth of the second half of XIX – the beginning of the XX centuries are used in work. The analysis of works of L. Gurlitt «About creative education» M., 1911 (Gurlitt, 1911); «Problems of general uniform school» SPB, 1914 (Gurlitt, 1914) are important.

The approaches realized by us reflect unity of the main directions of the principle of historicism in historical and pedagogical science.

3. Discussion

Publications about the innovative ideas in pedagogics of Germany for the first time appeared on pages of the magazines «Russkaya shkola», «Dlya narodnogo uchitelya», «Vestnik vospitaniya», «Svobodnoe vospitanie», «Narodnoe obrazovanie», «Obrazovanie» at the end of XIX – the beginning of the XX centuries. The majority of such materials had informative character and was written on the basis of personal impressions of trips abroad.

Achievements of teachers of Germany of the considered period were studied by the Russian teachers of the beginning of the 20th century E. Dzhunkovska, V. Dinze, A. Zelenko, S. Znamensky, P. Kapterev, S. Levitin in more detail.

Interest in the newest pedagogical currents of Germany amplified in Soviet period. L. Gurlitt, G. Sharrelman, F. Gansberg's main works and others were transferred to Russian. The main attention in them was paid to the analysis of activity of skilled schools.

The book by A. Piskunov «The theory and practice of labor school in Germany (to the Weimar republic)» (1963) (Piskunov, 1963), publications and V. Klarin's theses «The pedagogical ideas and school practice of revolutionary social democracy in Germany of the end XIX – the beginning of the XXth century» (1973) (Klarin, 2009), L. Obraztsova «Humanistic pedagogics of Germany of the end of XIX – the beginnings of the XXth centuries of 1870 – 1933» (2002) (it is model, 2002), I. Batchayeva «The theory of new «free education» of teachers reformers of the Bremen school of sciences of Germany, the end of XIX – the beginning of the XXth century» (1999) (Batchayeva, 1999) were the significant contribution to studying of this problem.

M. Boguslavsky, G. Kornetov, Z. Malkova, N. Nikandrov, Z. Ravkin are modern researchers of a problem of free education in Germany of the second half XIX – the beginnings of the 20th centuries (Boguslavsky, 2002; Cornets, 2009; Malkova, 1992; Nikandrov, 1995; Ravkin, 1994).

4. Results

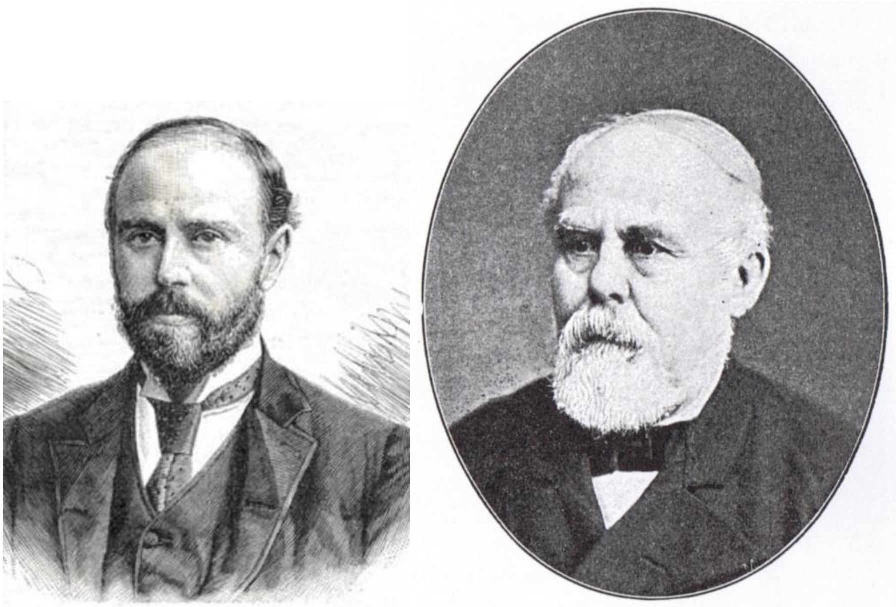

Fig. 1. Fritz Gansberg (1871-1950) Ludwig Gurlitt (1855-1931)

Fig. 2. Genrikh Sharrel'man (1871-1940)

Fritz Gansberg (1871-1950), Ludwig Gurlitt (1855-1931) and Heinrich Sharrelman (1871-1940) are figures of the Bremen school of sciences, founders of the concept of new «free education» (the theory of the personality). They were prominent teachers reformers of Germany of the end of XIX - the beginnings of the XXth centuries. They criticized authoritative pedagogics and modern school. These institutions did not satisfy vital interests of the people. These authors developed the axiological fundamentals of pedagogics reviving humanistic traditions. They considered education the leading means of formation of the humane personality. Researchers considered the personality the highest value of society. Teachers reformers did not connect humanistic valuable orientations with politicization and ideologization of education and education.

The humanistic ideas of teachers reformers at the end of XIX – the beginning of the XXth century updated new currents and the directions in pedagogics. They recognized the child by the main value and put him in the center of teaching and educational work. The alternative schools which arose on this basis (country boarding schools, anthroposophic, skilled and others) are their fundamental heritage. Therefore objective assessment not only foreign pedagogical theories, but also the best practices of schools gains exclusive importance in the light of modern pedagogical thinking.

Attention of the Russian scientists to experience of formation of spirituality at children and youth, interest in cooperation pedagogics, humane and personal pedagogics, a problem of overcoming authoritarianism, identification of forms adequate to modern living conditions and methods of training and education, search of ways of formation of creative potential and skill of the teacher humanist cause scientific and practical interest in humanistic pedagogics of Germany of the end of XIX – the beginning of the XXth century.

The constructive approach to the theory and practice of education in Germany of the considered period was caused by scale of economic, political and sociocultural processes in the country. Germany became the advanced state which entered a market stage of development. Powerful growth of economy, scientific and technical progress caused also continuous intensive development of education, science, culture. The pedagogics achieved considerable success. Reformatory currents were directed against authoritarianism in training and education, against scholastic school, its isolation from life.

The theories making demands of free personal development, training of the younger generation for work, creativity of formation of civic consciousness, universal morals, independence, amateur performance were widely adopted.

Experimental teaching and educational institutions were created. They successfully carried out versatile development of pupils, their education on the basis of universal values. The child, his personality, interests, tendencies, desires were in the center of their teaching and educational activity. Such approach to training and education demanded other, active interaction of the teacher and the pupil. The teacher turned into the organizer of versatile activity of pupils.

Teachers reformers considered education the leading means of formation of the humane personality. They considered the personality as the highest value of society.

F. Gansberg, L. Gurlitt, G. Sharrelman opposed class school, suppression of the identity of the pupil, bureaucracy in the system of national education. They defended need of versatile physical and spiritual development of children, the idea of the humane attitude towards them, free development of identity.

Long-term teaching work of L. Gurlitt in classical gymnasiums (Hamburg, Berlin) led him to a thought of discrepancy of the existing system of school education to requirements of development of the personality. He criticized contents and methods of training at the German schools, in particular in gymnasiums, in books «German and His Fatherland» (1902), «The German and his school» (1905) (Gurlitt, 1911). He considered the main problems isolation of their teaching from life, strong attention to classic languages and stories, unilateral orientation to examination and also authoritarianism of teachers.

According to Gurlitt, education should not pursue the practical aims. It is intended to direct the wakening force and activity of children. L. Gurlitt came to denial of need of systematic studies at national school. He said importance of communication of training and education with needs of practical life. The sport, games, walks, conversations on free subjects, etc. had to take their place. They were designed to cultivate will, reasonable discipline, independence of judgments (Gurlitt, 1911).

L. Gurlitt also demanded careful selection of a training material, an exception of training programs of minor material, improvement of esthetic education, introduction of classes in manual craft work. Gurlitt's pupils (from a gymnasium in Berlin) became initiators of the youth tourist movement «Migratory birds» (Gurlitt, 1914).

L. Gurlitt proved the provision that education should not pursue the practical aim. All forces and activity of children need to be developed. Sports activities, games, creative works it is necessary to enter. Traditional education needs to be replaced with esthetic occupations and different types of manual activity (Gurlitt, 1911).

G. Sharrelman sharply criticized traditional national school with a rigid regulation of activity of the teacher and pupils. The school has to be labor community of children. They have to set to themselves specific goals and look for ways of their achievement under the leadership of the teacher. Sharrelman understood the management of children as the cooperation having tactful character. He denied planning of educational process and its technique and defended free works of the teacher (Sharrelman, 1921).

G. Sharrelman acted from positions of pedagogics of the personality. He saw the main task of school in care of free spiritual development of children, in development at them joyful attitude. In this regard the teacher attached great value to independent creative works of pupils. He was a supporter of incidental and complex teaching. He considered unacceptable systematic and subject training for national school. The researcher ranked himself as supporters of labor school. But on the substance of G. Sharrelman defended the principles of active training and did not seek to acquaint children with real work (Sharrelman, 1921).

The teacher was even dismissed for protests against the system of training at public schools.

F. Gansberg also saw a way of formation of the identity of the child in stimulation of its creative self-development. He saw in it the education purpose. The teacher gave preference to a living word as the central method of training. F. Gansberg applied the story, conversations, compositions in student teaching (Gansberg, 1909).

These teachers developed the concept of new "free" education. The person is considered as the highest value in this concept. Comprehensively and harmoniously developed personality acts as an education ideal. Formation of the free personality owning a certain level of culture and also self-development of the personality is proclaimed the education purpose in the considered concept. The school is considered as one of fixed assets of development of physical and spiritual powers of pupils, developments at them of independence, vital activity (Gansberg, 1911).

The sense of education consists in achievement of balance of contradictions of the personality in the continuous movement aimed at the development of all forces in each child according to his identity on achievement of internal and external freedom, on mastering universal and national culture. Freedom of personal development was understood by teachers reformers as training of the independent and active acting people able to work creatively as manifestation of identity in the course of free creative activity in the conditions of cooperation.

Valuable orientations of education and education for the first time in the history of pedagogics were extended to formation of the identity of the woman in the concept of authors of new «free education». The humane and democratic orientation of this concept also affected in it (Batchayeva, 1999).

The new axiological interpretation of the principle of nature conformity of education is given by authors of the concept of new «free education». As humanistic value this major principle of pedagogics reveals in works of figures of the Bremen school of sciences from positions of an antropologizm and means the requirement of assistance to the child in his natural physical and social, spiritual development, in aspiration to independence and creativity, i.e. free personal development according to the life purpose and also «education by means of life».

Teachers reformers considered that the principle of nature conformity can successfully be implemented in practice of education when the teacher learns the child's nature as a product of culture and evolution, gets into the mystery of his identity and uniqueness (Batchayeva, 1999).

Proceeding from this principle, training has to be evident. «Organic forces» of the child, including ability to cogitative activity, demand it. The highest spiritual presentation which is the driving force of active cerebration has to be used in training also.

The presentation is necessary also in education. It means a support on life experience of the pupil on condition of full freedom in training and education and use of an example of tutors, the persons surrounding the child (Gurlitt, 1911).

Such approach to disclosure of essence of the principle of nature conformity of education promoted development of the anthropological bases of the theory and practice of modern training and education.

The concept of personal development created by teachers reformers was new valuable orientation in pedagogical science. Her authors supported transition from the existing authoritative education and dogmatic training to education and training as the independent productive creative activity of the pupil in all spheres of activity available to it which is carried out together with the teacher. Spiritual and physical forces of the pupil develop in its process.

Figures of the Bremen school of sciences saw incentives of original development of identity mainly in specially organized pedagogical environment. The relations of the tutor and pupils were under construction on the principles of cooperation in it. The teacher has to consider influence of heredity, individual distinctions created by the nature which are shown in unequal abilities. Motivation of activity of the personality to independent creative activity in the conditions of freedom, but not imposing of others ideas, views, beliefs and interests has to be the basis for development of natural powers and abilities.

However I. Batchayeva considers that F. Gansberg, L. Gurlitt and G. Shar-relman did not consider at the same time that stimulation of natural powers of the child, his independent creative activity is carried out not only in free, natural conditions, but also under the influence of social factors, in the course of socialization of the individual (Batchayeva, 1999).

Game as the activator of the healthy and free independent activity of the child corresponding to his abilities and requirements acts as a source and means of formation of the free, comprehensively developed personality in the concept of personal development of teachers reformers. Interaction of adults and children, manifestation by children of independence, activity and an initiative is necessary in a game.

Reformers recognized development of spirituality by one of the leading directions of formation of the personality. They thought of this development as satisfaction of natural aspiration of the person to knowledge. They considered that coercion is inadmissible in cognitive activity of the pupil.

However the problem of identification and accounting of his tendencies, interests and abilities arose in process of growth and strengthening of spiritual powers of the individual. On the basis of it they proved the idea of differentiation of training. Analyzing conditions of efficiency of different types of activity of pupils in development of their personality, teachers reformers proved success in achievement of the pedagogical purposes. Activity has to be carried out as free, easy and business cooperation of children and adults, as cooperation of equal persons.

Specific features of the child, its uniqueness need to be considered in the course of this cooperation. Disclosing essence of pedagogics of cooperation, figures of the Bremen school of sciences most fully characterized its such lines as trust and deep respect of the identity of the child, need of comprehensive study of his age and specific features (first of all – abilities) in order that in training and education «to proceed the child's willows» (Sharrelman, 1921).

They allocated the special place of the organization of «truly pedagogical life». The free relations between the teacher and pupils including the choice by pupils of maintenance of a training material according to their tendencies and interests and will of the teacher have to be their cornerstone. The school has to represent community of teachers, pupils and their parents. The joint efforts promoting formation of the free personality are inherent in this activity. Cooperation of teachers and pupils excludes the categorical bans directed to restriction of freedom of school students. The educational independence, intellectual freedom as exchange of views, are encouraged with views, beliefs in the course of the casual conversations. Also own relation is developed by studied. Classes are given according to the interests of trainees, «the easy design of a lesson» is allowed. The obstinacy as the line characterizing strong character of the pupil, manifestation of will power by it is encouraged in training and education.

The ideas of cooperation of teachers and pupils in pedagogical process in works F. Gansberg, L. Gurlitt, G. Sharrelman promoted updating of pedagogical science and school practice in line with their democratization and a humanization. These ideas were directed against the authoritative and imperative theory and practice of training and education.

The analysis of basic provisions of the concept of new «free education» of figures of the Bremen school of sciences allowed to reveal its contradictory parties. I. Batchayeva said that authors denied systematic training, planning of educational process at national school, defending free works of the teacher. They considered manual work the main means of labor training at elementary school. Teachers did not connect properly training in work with studying of theoretical bases of production activity (Batchayeva, 1999).

5. Conclusion

The concept of new «free education» developed by F. Gansberg, L. Gurlitt, G. Sharrelman had a positive impact on development of world pedagogical process. It was the movement to humanistic pedagogics. This system strongly weakened authoritarianism positions.

They considered education the leading means of formation of the humane personality. Researchers considered the personality the highest value of society. The main ideas of figures of the Bremen school of sciences this creative use of the ideas of pedagogics of cooperation, interrelation of training and education, the theory and a technique of labor training and education began to be applied widely in activity of the Russian teachers of the democratic direction. These thoughts cardinally changed philosophy of educational activity of the Russian school and customized all educational system of Russia on essentially new harmony.

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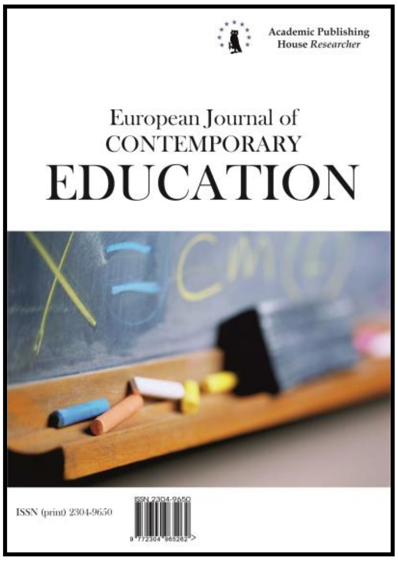

Development of School Education in the Vologda Governorate (1725–1917). Part 1

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Abstract

The paper highlights early steps in the development of the school system and its progression with a focus on the Vologda governorate in 1725–1917. Speaking of the materials, this part reviews the works on the history of pedagogy published in the pre-revolutionary period, as well as modern Russian scholarly literature.

Research problems were addressed using both general scientific methods (concretization and generalization) and traditional methods of historical analysis. The work applied the historical and situational method which is based on the study of historical facts in the context of the period under review and in connection with "neighboring" events and facts.

In conclusion, the authors emphasize the fact that the system of public school education in the Vologda governorate in 1725–1850 underwent rather dynamic evolution – from arithmetic schools and theological seminaries to the creation of uezd schools and a gymnasium. The teaching staff at Russian gymnasiums was requested to conduct almost obligatory research as early as in the 19th century, and this, in turn, enhanced efforts to study various regions of the Russian Empire and in particular the Vologda governorate.

Keywords: public education, gymnasium, schools, Vologda governorate, Russian Empire, teachers.

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1. Introduction

First research institutions in the Vologda governorate were established already in the fourteenth century. They were founded by Saint Stephen, the apostle and enlightener of the land of Perm, who preached the Christian doctrine among the indigenous pagan population (Popov, 1885: 40). Striving to strengthen Christianity among the people, the enlightener opened schools at churches and personally taught children the Book of Hours and other church books translated into the Zyriane language.

However, after the death of Saint Stephen, the written tradition ceased to exist in the land of Perm in no more than 100 years. Later, it was forgotten, as pastors endeavored to transfer the tradition from Zyriane to Slavic. School education was restored only under Peter I. In the first part of this paper, we would like to explore the development of the public education system in the period from 1725 to 1850.

2. Materials and methods

The materials used in the paper include the works on the history of pedagogy published in the pre-revolutionary period, as well as modern Russian literature.

Research problems were addressed using both general scientific methods (concretization and generalization) and traditional methods of historical analysis. The work applied the historical and situational method which is based on the study of historical facts in the context of the period under review and in connection with "neighboring" events and facts.

3. Discussion

A wide range of issues and aspects related to public education in the Vologda governorate has long been brought into the research focus of the history of pedagogy. Initially, this subject was studied in the context of the history of Orthodoxy, namely against the background of the activities of Saint Stephen of Perm in the fourteenth century. This subject was described or referred to by such researchers as E.A. Popov (Popov, 1885), N. Otto (Otto, 1866), as well as discussed in the work "For the history of Vologda directorate of schools" (Dlya istorii, 1860).

In the reign of Peter I, Russia initiated the process of creating educational institutions, namely, arithmetic schools and theological seminaries, which subsequently grew into secondary and primary schools, and later into gymnasiums and uezd (uezd – a district; in pre-revolutionary Russia, an administrative and territorial unit, divided into units called volosti, a component of the guberniya (governorate)) schools. The subject of public education in the Vologda governorate was spotlighted by pre-revolutionary Russian researchers such as: N. Bunakov (Bunakov, 1864) and A. Ivanov (Ivanov, 1879), as well as the "The historic overview of the activities of the Ministry of Education. 1902–1902" (Istoricheskii obzor, 1902).

In the recent period, the history of Vologda educational facilities was reviewed by such researchers as: N.S. Vorotnikova (Vorotnikova, 2015; Vorotnikova, 2015a; Vorotnikova, 2016) and L.N. Kolos (Kolos, 2015).

4. Results

In the eighteenth century, the area enjoyed the opening of government schools – arithmetic schools in Vologda and Ustyug under Peter I, theological seminaries in the same cities, and finally, public schools in different cities in the reign of Catherine the Great. However, the existence of arithmetic schools was very brief[*]. Moreover, the Ustyug authorities only implemented the concept as a mere formality: in 1725, they gathered 15 pupils there with a plan to teach them the primer and numbers, but since no teacher was found, the school was closed without delay (Otto, 1866: 9). The Vologda arithmetic school had a similar fate as the facility failed to find pupils (Dlya istorii, 1860: 66).

A more successful project was the foundation of the Vologda Theological Seminary that was opened in 1730 by a scholar and philologist, Athanasius Kondoidi. In 1738, a school for children of the clergy was opened in Ustyug and in the same year was reorganized into the Ustyug Theological Seminary. By 1744, the seminary already taught three classes – poetics, syntaxima and infima.

[*] An arithmetic school was opened in Vologda in 1714 (Dlya istorii, 1860: 65)

The total seminary enrollment reached 167 pupils (Otto, 1866: 10). However, after the Ustyug diocese was stopped, the seminary was closed and the remaining pupils were transferred to Vologda.

An important fact to be noted – in Vologda, even before the first Statute of Public Schools was published, the Department or *prikaz* (prikaz – an administrative (palace, civil, military, or church), judicial, territorial, and executive offices in Russia of 15th-18th centuries) of Public Charity, on the basis of the Statute for the Administration of Governorates, on November 7, 1775, recognized the need to take care of the education for orphans and children of poor parents. As a consequence, this initiative launched two charitable institutions in Vologda – an orphanage and a school. The orphanage was set up in 1784, and the school – a little earlier. According to the available data, already in 1781 the school curriculum included French, arithmetic and drawing; later, it was expanded to cover Latin and Russian grammar (Otto, 1866: 11).

In 1782, an order of Empress Catherine II established a commission on the institutions for public schools (Dlya istorii, 1860: 67). On August 5, 1786, the first general Statute of Public Schools was approved, and it ordained to open public schools in 25 governorates of the Russian Empire, including Vologda. According to the Edict in the same 1786, a secondary public school was opened in Vologda, and in 1787 primary public schools were opened in 5 other towns: Veliky Ustyug, Totma, Solvychegodsk, Gryazovets and Lalsk (however, in the latter two schools operated no more than a decade). So, only 4 schools operated in the Vologda governorate, of which the Vologda school alone was funded by the government, while the rest were supported by the local population.

It is known that there were 172 pupils in all Vologda schools in 1804 with 82 in the secondary public school, 38 in Ustyug, 30 in Totma and 24 in Solvychegodsk. The number included: nobles – 17, company officer children – 31, clerk (*prikaznye*) children – 30, merchant children – 7, townspeople children – 41, soldier children – 35, master's servants – 11. The operation of 4 schools required about 3,235 rubles of annual spending. The cost structure by school was as follows: in the Vologda school, salaries to the director – 500 rubles; to 6 teachers – 1,450 rubles; house maintenance, heating, lighting and servants – from 300 to 600 rubles. The sum total was 2,275 rubles. In the three-class Ustyug school (as of 1803): a teacher of the 3rd class – 250 rubles; a teacher of the two lower classes – 180 rubles; school maintenance – up to 100 rubles. In total, it was 555 rubles. In the Solvychegodsk school: a teacher of the 1st and 2nd classes – 120 rubles, house maintenance and teaching aids – up to 100 rubles. In total, it was 220 rubles. In Totma, a teacher's salary – 100 rubles, house maintenance – from 50 to 85 rubles. The sum total was around 185 rubles. (Otto, 1866: 15).

The curriculum in primary public schools was generally limited to elementary knowledge; only the Ustyug school, despite the reluctance of local inhabitants, introduced a historical class, and later opened the course of Latin, despite the strong resistance of Ustyug inhabitants. The resistance can be explained as local residents better needed the German language, accounting and commerce to do trade in Arkhangelsk (Otto, 1866: 18).

In 1804, the Moscow University sent to the Ustyug school books worth 297.5 rubles. As a result, a small collection of books was formed in the Ustyug school, and teachers were proposed to give out books to pupils and check the read material. In addition, other residents were also allowed to take books but for a fee of 3 kopecks per book (Otto, 1866: 19). It is important to note that the books purchased or donated included 5 antique books of Latin classics.

Despite the resistance of the population, a Latin class was opened in the Ustyug school in 1804.

We should also provide a brief description of other schools. The Solvychegodsk school began to operate on January 1, 1788 with 25 pupils. When the primary school was created by merchants and townspeople, it was decided to donate 60 rubles annually for its needs; but living in poverty, the community was unable to supply even this small money. In this situation, burgomaster (town mayor) Litvinov contributed a sum for school maintenance in 1788 with the endowment not to spend it on other needs. In 1801, the sum amounted to about 1 thousand rubles, and was called a merchant bank where the capital, thanks to the charity of other people, gradually increased, but, unfortunately, subsequent mayors and town councilors depleted the bank in violation of the philanthropic will (Otto, 1866: 21).

The orphanage was created in 1784, and according to the personnel chart it had 20 pupils. The orphanage admitted children from 8 to 17 years old, and the pupils included children of different estates: of nobles, officers, clerks and soldiers. Initially, wardens were a public school teacher and later war department representatives. Pupils wore a uniform: a frock coat, a vest and trousers of gray thick cloth, a leather felt peaked cap and an overall. A few years later, the pupil uniform was redesigned – gray frock coats were replaced with blue ones, and green peaked caps replaced with black leather ones.

On November 5, 1804, a new Statute for Educational Institutions of the Ministry of Public Education was introduced in the Russian Empire. However, the Vologda governorate belonged to those few regions where the first gymnasium was opened even before the introduction of the new statute. In the late 1803, a Moscow University trustee, M.N. Muravyov, sent the lexicon, 4 grammar books and one Latin reading book to the administration of the Vologda public school with a proposal to start teaching Latin. The trustee's proposal was soon put into practice. To this end, the administration selected 20 pupils, including 2 from noble families, 3 of the officer estate, 7 of the clerk estate, 5 of the soldier estate, 1 of the townspeople estate and 1 of the free estate (Otto, 1866: 24-25).

On August 18, 1804, the Vologda secondary public school was reformed into a provincial gymnasium. With the pedagogical staff shortage, teachers were invited via classified advertisements in the Moskovskiye Vedomosti newspaper. In 1806, the gymnasium founded an extraordinary jurisprudence class for senior gymnasium students.

To improve financing in uezd schools, in 1811, the position of honorary superintendent was introduced, who was elected from the merchant community and was obliged to annually donate sums for public education needs (Dlya istorii, 1860: 80).

The Directorate of Vologda Schools was under the jurisdiction of the Moscow School District until 1825, and the Governing Senate's decree of December 31, 1824, assigned it to the Petersburg School District.

Over the first 20 years of its operation, the Vologda gymnasium was visited several times by Moscow University professors. In 1832, the Vologda gymnasium was reorganized and henceforth had 7 classes instead of 4 classes*. It is necessary to note that over 60 years, in the period from 1804 to 1863, the number of students in the Vologda gymnasium varied greatly from 23 people in 1824 to 242 in 1847 (Otto, 1866: 45-46)

It is also interesting to look into the distribution of students by estates and classes (Table 1 and Table 2).

Table 1. Students at the Vologda gymnasium in the breakdown by estates (Otto, 1866: 46)

Years	Total number	Children of nobles	Children of company officers	Children of distinguished citizens	Children of merchants	Children of townspeople	Children of the clergy	Children of clerks	Children of soldiers	Children of free people
1809	44	6	19	-	1	3	-	9	4	2
1835	106	42	54	1	5	4	-	-	-	-
1836	129	55	62	1	6	4	1	-	-	-
1841	224	96	104	1	5	16	2	-	-	-
1844	195	76	89	2	7	20	1	-	-	-

* Studies lasted 5 years: the 1st, 2nd and 3rd classed were allocated one year each and the 4th class – 2 years (Dlya istorii, 1860: 82).

Table 2. Students in the breakdown by classes (Otto, 1866: 47)

Years	Total number	Classes						
		1st	2nd	3d	4th	5th	6th	7th
1809	44	16	11	8	14	-	-	-
1832	69	17	14	10	12	7	5	4
1841	230	30	43	51	38	16	31	21
1845	200	28	26	37	32	28	29	20

In the early nineteenth century, with outbreak of the war of 1812, many nobles hurried to joining the army, leaving the institutions where they studied. As a result, the number of students in the Vologda gymnasium was not large at that time too, and continued to go down as young people were called out to St. Petersburg to do the military service.

The library at the Vologda gymnasium and its physics and natural history classrooms were replenished thanks to donations from various individuals. For example, there were about 500 book titles in the gymnasium's library by 1824, and the classrooms had 26 physical and geometric instruments and devices, 15 geometric wooden solids, 4 globes, 229 fossil bodies, an herbarium arranged according to the De Candolle system, including 200 dried plants, 102 seeds and 91 shells (Otto, 1866: 52). However, it would be unfair to omit the role of the government in providing educational institutions with course books. For example, already at the time when the Vologda gymnasium was established, the trustee of the Moscow School District, M.N. Muravyov ordered to allocate 1,5 thousand rubles to the Vologda gymnasium to purchase books. The library also received new titles from benefactors on the gymnasium's inauguration day. It is known that the Chairman of the Civil Chamber, Petrov, donated 116 books in German, and the daughter of the former inspector of the Vologda medical office, Yak. Friza, donated 118 books in German (Dlya istorii, 1860: 71).

There also were other sources that provided new items to the library. For example, in 1808, the gymnasium bought 8 essays for 374 rubles, which were auctioned at the University of Dorpat (duplicate copies) (Otto, 1866: 53).

Another noteworthy fact is that a number of teachers at both the gymnasium and schools were engaged in collecting a broad variety of scientific data. Moreover, the University of Vilna sent information in the school district so that naturalists gathered materials in the areas such as witchcraft, folk medicine, natural minerals and dye reserves. Concerning witchcraft, the university wanted to know answers to the following questions: what items of the kingdoms of plants, animals and fossil minerals witchdoctors used in their art, in particular what kind of plants do they utilize to cast spells against snake bites and other reptiles, as well as how they treated various internal and external diseases of people and animals, Polish plait (Plica polonica), hernia, how they sent insanity and treated it, how they did harm to bees or lure them into their beehives, how they charmed guns and removed the spells? Naturalists were also asked to accurately specify the names, harvesting time and method of such plants, and, if possible, to send them to the university, in the dry or fresh form or in seeds (Otto, 1866: 65).

In the late 1828, a new Statute of Educational Institutions of the Ministry of Public Education was ratified in Russia. However, the reorganization of the Vologda gymnasium was slowed down by an outbreak of cholera in the city. The gymnasium was transformed only on April 3, 1832. Following the reform, the curriculum started to include: Law of God, sacred and church history; Russian philology, logic and grammar; languages: Latin, German and French; mathematics, up to conic sections inclusive; geography and statistics; history; physics; penmanship, drawing and sketching (Otto, 1866: 74). At the same time, the number of students reached 88 people. The enrollment included hereditary nobles – 23, personal nobles – 52, merchants – 3, townspeople – 5, raznochintsy (literally "people of miscellaneous ranks"; a social estate that included the lower court and governmental ranks, children of personal nobles, and discharged military) – 5. The term of gymnasium study was extended to 7 years, and in uezd schools from two to three years (Dlya istorii, 1860: 74).

Uezd schools taught the following subjects: Law of God and sacred history, reading of the book "On duties of man and citizen" (O dolzhnostyakh cheloveka i grazhdanina), Russian grammar, penmanship, orthography, syllabic division rules, general geography and fundamentals of mathematical geography, Russian geography, history of the world, Russian history, arithmetic, fundamentals of geometry, fundamentals of physics and natural history, fundamentals of technology related to local conditions and manufacturing, sketching (Dlya istorii, 1860: 84-85).

In 1835, the gymnasium introduced several improvements to the teaching organization. For example, to support teachers, tutors were chosen from the best students to explain and check lessons of weaker students. To maintain order and discipline in classes, monitors were chosen from reliable students of the 7th class. The children of poor parents, who demonstrated particular progress were given allowances for clothes from the budget determined for pupil awards.

On September 8, 1835, a noble high school was started at the Vologda gymnasium. Noble families of the Vologda governorate made provisions as early as in 1834 that the established educational facility should have 30 students, and the yearly tuition fee was 400 rubles per student. The school was supposed to have three supervisors: a Russian, a German and a French. Beginning in November of the same year, the gymnasium introduced the course of Greek.

Since 1850, the Directorate of School Districts made it a requirement that the teaching staff should submit research works. This in turn led to a significant number of new projects accomplished by teachers. Some of the works received preliminary approval from the Directorate and were published in the provincial newsletter. The best studies were sent to the Ministry of Public Education. It is necessary to note that a significant part of teachers would subsequently continue to pursue this line of activity almost until 1917. To improve the quality of the materials received, the Vologda Directorate, in collaboration with gymnasium teachers, developed guidelines on research work for history, geography, physics, chemistry and other sciences (Otto, 1866: 87).

Their efforts soon came to fruition, and along with first modest experiments, they started to receive essays with rather strong content. Some of the best works sent by teachers included “Fairs in Vashka in the Yarensky uezd” (Yarmarki na Vashke, v Yarenskom uezde), “Hunting for squirrels” (Okhota za belkoy), “Information on the Solvychegodsk cathedral” (Svedeniya o Solvychegodskom sobore), “Description of peasant wedding customs in some uezds” (Opisaniye svadebnykh obychayev krestyan nekotorykh uezdov) and other. These research initiatives refreshed local provincial news sheets that acquired good correspondents among teachers who provided a lot of interesting information on the governorate. This way was laid the foundation for the start of exploration into the Vologda governorate.

On the other hand, the senior school management initiated and encouraged gymnasium teachers to carry on scholarly, scientific and literary work. The rector at the St. Petersburg University, who was responsible for the school district at the time, reported in 1840 to the Vologda Directorate that the trustee of the Kazan University, when he audited the entrusted gymnasiums, noted that teachers mostly limited themselves to curriculum materials, taking no care of any research. As a result, he issued an order in 1838 that required teachers to discuss the branches of knowledge they taught, analyze books, perform translations, deliver statistical, ethnographic, topographical and historical research, as well as collect and record local lore and legends. The best works were planned to be published in the “Zapiski Kazanskogo universiteta” journal (Otto, 1866: 92-93).

In 1845, by ordinance of the school management, literary conversations were introduced to read and review the essays of the 6th and 7th class students (twice a month) to enhance academic performance and strengthen the practice of the Russian language and literature.

The curriculum, which was determined by the Statute of 1828 and finally settled down only in 1832, remained in force and with changes at that only until 1849, when a fundamental shift again took place in the gymnasium program. A totally new subject was introduced in the three higher classes as an experiment – jurisprudence. The course in Latin was reduced from 7 years to only 4 (Dlya istorii, 1860: 89), and natural history was now taught in all classes (Otto, 1866: 94-95). With the regulation of 1848, the public education obtained inner integrity and systemic view (Shevchenko et al., 2016: 366). The provision expanded programs in the gymnasium curriculum and also set forth an increasing number of uezd and parochial schools, but the key achievement was that the dispersed educational facilities in the region were brought together under a single center (Kobakhidze, 2015: 87-88).

5. Conclusion

Summarizing the above points, we would like to note that the system of public school education in the Vologda governorate in 1725–1850 underwent dynamic evolution – from arithmetic schools and theological seminaries to uezd schools and a gymnasium. The teaching staff at Russian gymnasiums was requested to conduct almost obligatory research as early as in the 19th century, and this, in turn, enhanced efforts designed to study various regions of the Russian Empire and in particular the Vologda governorate.

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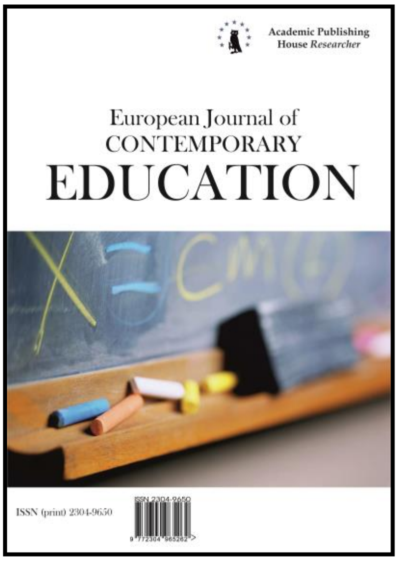

Apprenticeship in Secondary Vocational Schools during the Economic Modernization in late Imperial Russia. Part 2

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Abstract

In his study of the formation of apprenticeship system and analyzing its content, methods and forms in the Russian secondary vocational school described in the materials of the Kazan school district of the late XIX – early XX century, the author relies on the theory of Western modernization and positive bureaucracy, attracting regulatory and educational documentation, scientifically and publicly pedagogical journalism as well as ego documents.

Practical methods of knowledge application were planned in the pre-revolutionary schools in the logical-pedagogical relationship, but their implementation left much to be desired. In the organization of production practice, this was due to the lack of permanent bases and practical managers from the educational institutions, a certain attitude towards the trainee at enterprises as auxiliary personnel engaged in versatile non-system work, as it was openly declared by the advanced pedagogical press and even by the administrative and training personnel in schools.

The article also reveals positive aspects in the organization of practical training, which are still relevant today. These include the introduction of active learning methods, improved reporting documentation, payment for the students, preparing them for the future profession and management.

The rapid development of practical training was due to the need of a qualified young specialist who was prepared for independent production activity in the new conditions of accelerated modernization of the country's economy.

Keywords: Russian Empire, the history of education, training, practice, internship.

Introduction

We would like to present the final (i.e. second) part of our article on the formation and

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serious transformation that the organization of practical training in secondary vocational schools of the Russian Empire underwent during the modernization of the country. The first part of the article (Magsumov, 2018) covered general issues of the organization of practical training of students and revealed its specificity in the oldest types of vocational schools in Russia, i.e. agricultural schools. In the second part of the article, it is our aim to show the way practical training took place in technical, commercial colleges as well as nautical and river transport schools in late-imperial Russia.

4.3. The organization of practical training in technical and commercial schools at the beginning of the 20th century

Along with agricultural schools, industrial schools were also characterized as having certain deficiencies in terms of industrial practical training. Of course, the students' practical work in the workshops and laboratories of the vocational schools they attended contributed to their more complete understanding of special subjects and complex technological processes in industries. However, achieving the goal of linking education with real life was hampered by the fact that schools did not always have the equipment that met such goal.

Industrial practice took a significant share in the program of the chemical-technical education of the Kazan Industrial College (KIC), which was mostly carried out in college chemical laboratories and technical-chemical workshops, and occasionally in factories around the city (NART. F. 121. Op. 1. D. 166. L. 2). In the first grade, nine hours per week were allocated for practical classes held in the locksmith's workshop. The students were to acquire skills in metal processing using various types of chisels, filing surfaces, scraping and manual grinding of planes, threading, riveting, soldering, tinning.

The second half of the grade was devoted to the study of methods of connecting pipes and ensuring their tightness, as well as servicing various equipment: pumps, presses, steam boilers and steam engines. In the second and third grade, students practiced in the chemical laboratory at the KIC. The main purpose of those classes was to master the students' skills of performing various types of analyzes. As the final part of the studies, the students had classes in the technical-chemical workshops. The third-grade students were to spend 8 hours in those workshops, whereas the fourth-grade ones were given 20 hours. Those classes were supposed to improve the students' understanding of the basics of chemical production and introduce them to real-life technological processes as well as to the machinery most frequently used in the chemical industry.

We have already mentioned that, just as it took place in agricultural education, rules were also developed for industrial schools students that regulated working in factories and industrial plants. Much more emphasis was placed on the prevention of accidents rather than on the aims and content of the practice. The first paragraphs of the rules covered disciplinary aspects and were similar to the "Instruction for the trainees of agricultural schools". There was a difference in the sixth paragraph of the rules, which forbade pupils to have conversations with workers, if that was not related to the technical side of production, and, apparently, was aimed at reducing the mutual influence of the students and workers (Litvin, 2016: 716; Nizamova, 2013: 165). The second part of the rules covered occupational safety requirements, prescribing all types of operations and work. A number of paragraphs were quite simple and seemed natural; their inclusion was partly explained by the fact that the students were adolescents prone to various pranks. For example, it was forbidden to open protective equipment of production machinery out of sheer curiosity, or stop operating machines. In addition to general technical requirements, the rules were specified for students of various specialties. Thus, there was a section dealing with work on buildings for construction-technical schools: students were forbidden to run through the scaffolding and along walls of buildings being erected, climb up the rafters and roofs if that was not required, as well as they were not allowed to stand on the edges of unfortified slopes during earthworks operations (NART. F. 121. Op. 1. D. 292. L. 1-2). The reason was quite understandable as all that could lead to damage to the equipment and industrial injuries. However, concerning the issue of students safety, the Ministry of Education (ME) was not so principled compared to providing the system of prohibitions and allocation of funds. Even in 1913, an application made by one of the trustees of educational districts for permission to insure trainees failed to receive the approval of the ministry, which eventually issued a mere decree concerning a strict and precise observance of all safety measures (Laurson, 1916: 806). The same trend can be also observed in the letter issued by the ME in 1915 "On the introduction of protective goggles (the system of Prof. Donberg – T.M.) for the students of industrial schools" (Laurson, 1916: 989).

Recommendations for the implementation of safety measures in the industrial schools were stated much earlier than the rules on working at factories. This, it was stated in the ministerial exemplary programs that "rules are to be drawn up and posted concerning works in the laboratories (the schools' chemical laboratories – T.M.), which are to include the rules for handling chemicals, utensils, devices and instruments" (Uchebnye plany, 1891: 57). In the KIC, such rules were drawn up, but it is rather difficult to find out whether such regulations were actually placed in the laboratories due to the partial representation of the room in the available photos and low resolution of the images. However, in one of the photos, a paper poster can be seen placed on the wall, and there were notebooks on the table (Grigoriev, 2006: 31-32). Having a neat copybook was taken into account when grading the student for the practice, while keeping notebooks during the experiments was ensured by providing a fairly large workplace for each student, as it can be seen from the photos of the chemical laboratory of the Saratov Technical College (SarTC) (Saratovskoe, 1903: 162-163).

In order to make the students fully familiar with the production being studied, the school provided them with a program of classes to study various types of production. Upon completion, the students were required to provide a report on their classes at the factory or plant, which was to reflect the results of observations, information from work managers collected on site, drafts and detailed drawings of particular parts of buildings, appliances and machines (NART. F. 121. Op. 1. D. 292. L. 1).

The specificity of the Votkinsk Secondary Mechanic-Technical College (VSMTC), originally established at the Votkinsk industrial plant, was a focus on this particular enterprise, which is why all the practice activities of its students were held exclusively there. The fourth-grade students were engaged in assembly works in mechanical workshops, making drawings, as well as studying particular industries in practice. They also monitored the way boilers and other machinery operated, took care of them, monitored the sequential progress of the production of individual parts of locomotives and agricultural tools in various workshops. An observation log was compiled that included a list of the last types of the student's practical activities, which was to be submitted to the examination board, as the board considered all the calculations made by the student to the drawings of the steam engine and turbine and to the project in one of the mechanical production industries studied at the school (or in electrical engineering) (AOAV. F. 319a. D. 7. L. 25-25 rev.). Concentration of the entire production practice in one enterprise, in our opinion, allowed not only to improve coordination, monitoring and counseling of the students but also provided a more systematic approach to forming their competencies through familiarization (i.e. observation and demonstration of work activities) and participation (i.e. doing exercises and using active training methods) of the students in all cycles of the production process of certain products, as well as in the activities of various functional production units. This statement can be proved by the conclusion of the 1912 examination board on mechanics that consisted of teachers and engineers of the industrial plant, "Practical work activities on mechanics were performed excellently, the college staff made a full use of the possibilities of the students' constant interaction with numerous factories and workshops of the industrial plant" (AOAV. F. 319. Op. 1. D. 508a. L. 9).

The curricula of commercial colleges as educational institutions being quite close to comprehensive school did not involve practical training. They only carried out practical exercises in particular subjects. The larger, in comparison with the state schools, freedom of these schools and the corresponding environment became the basis on which a number of innovative ideas concerning practical training were implemented. The first congress of directors of commercial colleges in 1901 made an appeal to introduce the solution of problems "taken from real life and having a place in life" into practical training. Based on specific examples of describing that approach and its characteristics such as "designed practical exercises," the same task for the entire class "under the teacher's direct supervision", "one such independent work will teach incomparably better than even a conscientious study of ... a textbook" (Materialy, 1901: 132-134), we can discuss mere beginnings of the introduction of active and project-based teaching methods in a commercial college. The positive results of their use can be more objectively traced as remembered by the graduates rather than by analyzing the teachers' reports. Thus, B. Simonov, the head of the Kirov control laboratory for measuring equipment, recalled that during the time he studied merchandising at the Vyatka Commercial College (VCC) their class was divided into several groups, each was given a specific task. His group studied soap: first, the teacher recommended certain literature for them to read, and then suggested making soap themselves. The students were given money to buy beef tallow and vegetable oil, which were not provided by the laboratory, and then they made grained, marble and liquid soap according to the instructions found in the literature. After that, the teacher suggested making toilet soap, in particular, the so-called "Kazan soap" made with the addition of nitrobenzene. The students were again recommended certain books, then they "quite independently" prepared nitrobenzene in the laboratory and then made "Kazan soap" (Chunikhina, 1958: 154).

We can trace the practical training of those studying merchandising on the materials of trade colleges. Upon completing their third grade, the students at the Kazan Trade College (KTC) were sent to get practical experience to the commercial and industrial establishments of Kazan during their summer vacations. Thus, in 1913, 18 students became trainees. The school's pedagogical committee sent 38 letters to various companies and institutions, six of which agreed to accept the students (NART. F. 312. Op. 1. D. 32. L. 1). Although the traineeship was supposed to last at least two weeks, some students worked much longer (NART. F. 312. Op. 1. D. 32. L. 10, 12). At the end of the practice, all the students received practical training certificates.

4.4. Practical activities during the navigation period: water transport and nautical schools

No other type of vocational schools had its industrial practice so closely tied to the time of year as the water transport colleges. Since the opening of navigation (not earlier than April 1) to October 1, students of water transport colleges made a practical navigation by riverboats. Senior graders worked as helmsmen and pilots, whereas other students worked as sailors. Thus, in the 1913-1914 academic year the students of the Kazan Water Transport College (KWTC), "were taking part in practical navigation onboard of river steamboats in the following ranks:

Captain's mate – 6
Watchman – 8
Trainee – 20
Helmsman – 4
Sailor – 14" (Otchet, 1915a: 19).

A KWTC trainee had a navigation log and drew a map (in the Volga river map that every student had available; he made "corrections to the changing midstream of the river, putting down signs to find the fairway," as well as pointed out "hydraulic structures, distinctive coastal and waterborne signs, etc."). He finally received an assessment mark for that, the one that was crucial for transfer to the next grade along with the exams results in theoretical disciplines. This form of reporting was inspired by the head of the school even before the KWTC establishment, when he, while preparing a report on water transport colleges, was "at times exchanging letters with the captains of steamships where students would work as trainees". (TsANO. F. 1770. Op. 549. D. 7. L. 21 rev.).

In their logs, the students of the Oryol Water Transport College (OWTC) put down various cases, accidents, acts, as well as gave a characterization of the river, drew the scheme of the steamship and difficult rifts (Otchet, 1916: 19). However, a year earlier, i.e. in the third year since the college had been established, the students' logs, "contained various cases of practical navigation, order of work, sketches of the fairway, types of vessels and drawings of interesting details they encountered" (Otchet, 1915b: 17). In the latter case, one can conclude that the set of tasks for practice was rather superficial. That might have been due to the specifics of organizing the practice and individual characteristics of both the teachers and students; though in terms of chronological comparison, a gradual improvement in the forms of practice reporting can be seen. This is supported by the fact that all the KWTC documentation, related to the organizational aspects of the practice, was compiled in a strict unified form, including requests to accept the student as a trainee as well as the student's reporting form addressed to the head of the college informing the latter of the fact that the student had been accepted to improve his practical navigation skills (TsANO. F. 1770. Op. 549. D. 18. L. 1).

Of great importance for obtaining practical skills in the specialty was the position (or the range of duties, if the student was taken as a trainee without any temporary employment) which the student took during the practice. For example, the students of the Astrakhan Nautical College (ANC), while onboard of a training ship, studied marine service in practice, carrying, as crewmembers, watch-keeping duties, participating in shipboard, emergency and alarm works, also performing special practical tasks at a given time (Vinogradov, 1908: 59). If a student carried out auxiliary or other activities that did not meet his specialty during his traineeship, then, obviously, he received a superficial experience or even got a wrong idea of the nature of his future professional activities. Thus, M.V. Cherepanov, the head of the KWTC, explained this situation at the III Congress of Russian specialists on vocational education. In his report, he mentions, that senior graders of water transport colleges, those who had had a few navigations, were accepted to the steamship crew as helmsmen or pilots. Other students with no experience in navigation were taken as crewmembers above the specified number on tow-boats; they were eventually turned down by passenger ships due to the lack of space for an extra person. However, the trainees "that are accepted as sailors, tend to become like other crewmembers, and by doing unprofessional duties and simple work of the river steamship sailor, develop only physically without acquiring proper practical knowledge; and besides, being in constant contact with the sailors, such students are exposed to the corrupting moral influence of the sailor environment. Those students, being accepted as extra people above the specified number of the crew of the ship, sometimes without being paid, perform such duties, which are considered as being not worthy taking the deck crew away from the work, such as keeping guard at the gangway, mopping the deck, running on errands and so on" (TsANO. F. 1770. Op. 549. D. 7. L. 200-200 rev.).

Nautical schools trainees were rarely admitted to using navigating tools and equipment because of the fear of their damage by the students, the provision of private ships with such tools being quite insufficient. The traineeship as a sailor deprived the student of his free time and a proper place to perform his practical tasks for the college as well as to improve the acquired knowledge. For a trainee, the position of a sailor was not the worst outcome as he received payment from a private shipowner, but if he was accepted as a "pupil," then he himself had to pay the shipowner. The pupils who got on the training ship were provided for, including free food and laundry, at the expense of the ME, though a certain part of the expenses was covered by the nautical colleges' special funds (Vinogradov, 1908: 58-60). However, when discussing the draft of the reform of nautical education, the ANC trustees board suggested that the traineeship "be performed by students on commercial vessels, and not on training ones" (Mneniya, 1910: 221). The reasons for such proposal are unclear, we can only assume that independent practice, including finding a ship to have practice and concluding an agreement with its owner, allowed the trainee to get "directly" engaged in real-life conditions of subsequent labour activities and master different types of such activities. The experience of the Nizhny Novgorod Water Transport College might serve as proof to that version. The governor of Nizhny Novgorod, N.M. Baranov, a patron of the college, who himself was a former naval officer, in an effort to provide students with a decent income, asked shipowners to accept those students as assistants and cashiers. However, due to the fact that the trainees were actually not prepared for such a complex, and even administrative, activity, the shipping companies tended to turn the students down under plausible excuses. Later, a special position of a "trainee" was introduced whose responsibilities included helping the cashier and assistant. Moreover, for employment, one had to have a certificate of a preliminary practical knowledge issued or signed by a person/persons the shipping company was familiar with; in this case, the recommendations issued by the vocational school's board of trustees became null and void (Dvadtsatipyatiletie, 1912: 40-43).

However, the practice bases themselves had problems with the education of their employees as practice managers from certain enterprises and companies. As a significant problem in organizing the practice of students of river transport colleges, the KWTC administration directly referred to the lack of special education, and often the lack of literacy and even the fact of total illiteracy of most of the captains of river steamships, especially tow-boats, which made them mediocre student supervisors (Ocherk, 1915: 12).

If in secondary vocational schools industrial practice was closely related to school subjects and was to provide students with the initial professional experience, thus consolidating, generalizing, expanding and deepening their theoretical knowledge through its application in real-life activities, then in lower vocational school, it was practical training that almost completely replaced theoretical training.

5. Conclusion

5.1. Practical training was the most innovative element of the educational process in a secondary vocational school due to the need for it to be adequately aligned with actual industrial practices for modernizing the country's economy. Because of this, in the reform of practical training, a combination of the positive position of the educational bureaucracy and the proposals of the social-pedagogical movement could be observed. This was reflected in the increasing role of practice in the educational process as more academic hours were allocated for such activities, reporting documentation was gradually improved, which included a detailed report, student's log and review from the practice base. In addition, active teaching methods were being implemented at that time.

5.2. All the basic traditional methods and forms of industrial practical training used in modern vocational education were already introduced in the pre-revolutionary school. Practical training was implemented in the forms of practical classes in academic disciplines, in the specialty in college laboratories and workshops, and traineeship at specialized enterprises.

5.3. Despite the fact that forms of practical training were striving for uniformity, their dependence on the types of vocational schools and areas of training was quite substantial. However, by the beginning of the 20th century, in general, it was the priority concept of teaching first practical actions that characterize the functionality of lower-level workers and specialists and then forming skills within secondary vocational education that prevailed in the system of practical training of secondary vocational school students. This consistent alignment corresponded to the logic of the formation of basic and special skills, but clearly demonstrated the lack of continuity between lower and secondary vocational schools in terms of training personnel and any introduction of polytechnical education into the system of secondary education with the rare exception of high-quality optional manual labour classes in certain schools.

5.4. A common feature that all the practices outside of the educational institution shared was a set of administrative functions to be learned by the trainees who were going to take employment positions that required combining the functions of specialists and middle-ranking managers. At the same time, the school structure itself did not allow to prepare leaders or innovators, and vocational schools had to pay special attention to this functionality in the normative documents concerning the practice through a bureaucratic system of prohibitions and behavior restrictions. The educational authorities had a similar trend: they had introduced a safety system, but avoided covering the costs of its introduction.

5.5. Lack of permanent bases of practice and difficulty in finding and selecting them, as well as the independence of these bases from the school that did not appoint the practice leaders from the educational institution can be considered among the problems of industrial practices of that time. This led to, among other things, to the lack of control over the trainee's activities, as the students were likely to be treated by the enterprises as an auxiliary personnel engaged in doing the tasks that had little in common with the trainee's specialty. All that was aggravated by the motley contingent of vocational schools.

5.6. By the beginning of the 20th century, the increasing demand for specialists made it possible for trainees to do practical activities and be paid for that, while vocational school allowed to start selecting practice bases and assign students to particular bases, which in general positively affected the quality of students' training.

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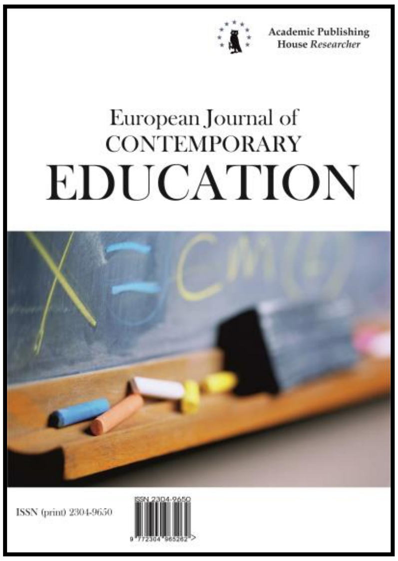

Teacher Training for the System of Primary Education in Switzerland in the mid-nineteenth century

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Abstract

The paper deals with primary education in Switzerland in the middle of the nineteenth century with a particular focus on the primary school organization in various cantons. It also reviews the training process of primary school teachers in Swiss teacher seminars.

The materials used include specialist literature on the research topic. The methods of research were the principles of objectivity, historicism, systemic, complex consideration of social subjectivity in the subject of study, the maximum possible neutrality of the researcher towards the interpretation and evaluation of the actual material was assumed. The use of these methods allowed the authors to consider the system of singing training in educational institutions in retrospect and in historical sequence.

Summarizing the discussion, the authors concluded that the government turned its attention to talent training for primary schools almost as soon as primary education was introduced in Switzerland in the 1830s. Such training entirely fell on the so-called normal schools – seminars preparing teaching staff, which were divided into two types – men's and women's institutions. Despite the existing diversity of teaching formats in different cantons in Switzerland, the Confederation government made considerable efforts to unify education in the country. On the other hand, in competing with other cantons, independent cantons were committed to bringing only best practices into the public education system.

Keywords: teacher seminars, Switzerland, primary education system, mid-nineteenth century.

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1. Introduction

The formative years of public education has its distinctive and characteristic features in different European countries. The rise of teaching profession, as a rule, was influenced by a country's geographical location that further brought about economic and demographic factors. By the mid-nineteenth century, Switzerland was one of these countries. By this period, Switzerland had been able to accumulate sufficient expertise in education and held a leading position in Europe, based on a number of indicators (Belyavskii, 1897: 1). In the paper, we aim to consider the peculiarities of teacher training for the Swiss primary school.

2. Materials and methods

The materials used include specialist literature on the research topic. The methods of research were the principles of objectivity, historicism, systemic, complex consideration of social subjectivity in the subject of study, the maximum possible neutrality of the researcher towards the interpretation and evaluation of the actual material was assumed. The use of these methods allowed the authors to consider the system of singing training in educational institutions in retrospect and in historical sequence.

3. Discussion

Historically, the subject of primary education in the nineteenth century, both in Europe and in Russia, was interesting to a wide academic and pedagogical community. The search for new teaching formats and methods, transition to compulsory education and other challenges were often hotly debated on the pages of scholarly periodicals. That is why pedagogical journals and academic monographs placed great emphasis on the dedicated experience and insights gained (Shevchenko et al., 2018: 226-228). One of these topics referred to Switzerland's public education system. First publications on the topic began to appear in the 1860s. For example, the “Journal of the Ministry of Public Education” published two works by V. Varentsov (Varentsov, 1863) and a short commentary on public education in Switzerland (Narodnoe obrazovanie, 1862).

In the late nineteenth century, public education was highlighted by N.N. Belyavskii (Belyavskii, 1897) and I. Berlin (Berlin, 1898). At the end of the Soviet era, the topic of literary links between Russia and Switzerland in the eighteenth and nineteenth centuries was explored by R.D. Danilevskii (Danilevskii, 1984).

The post-Soviet period witnessed a range of researchers, such as Yu.S. Kukushkin (Kukushkin, 1995), L.G. Berezovaya (Berezovaya, 2012) and O.V. Kozlov (Kozlov, 2013) turning their attention to the subject.

4. Results

Before proceeding to the description of Switzerland-specific features of public education development, it is necessary to clarify that administratively the territory of Switzerland was divided into 22 sovereign cantons. Moreover, almost every canton had its own rules regarding public education (Kozlov, 2013: 113). For this reason, the Swiss government paid great attention to projects to unify education and find new optimum solutions.

The rapid spread of primary education in Switzerland was driven by the association of sovereign cantons into a single union in 1832–33. All cantons, except for Geneva, Valais and three minor mountain cantons on Lake Lucerne with a very small population, where it was not possible to establish a significant number of schools, adopted compulsory education. According to the law, all parents were required to send children aged from 6 to 14 to schools. In a number of communities, teachers received lists of all children in their wards, and checked pupils against the lists every morning; if a child was absent, they recorded the appropriate reason for the absence in the lists. The lists of pupils were regularly audited by inspectors who were granted the right to levy a fine for each day of absence on the parents of the absent child if no valid reason was provided. However, the law was not strictly enforced everywhere. There were even localities that did not require to unquestioningly obey the law at all.

Each canton in Switzerland was divided into communities or parishes, and it was mandatory for each parish to have a school in place to teach their children, as well as a salary and home for a teacher. Parishes which had more 20 children aged from 6 were supposed to establish a school. If the number of pupils reached 50–60 people, it was required to open a second school and so on.

Boys and girls often studied at the same school. Although parishes were not obliged to establish schools for young children, the government still recommended to launch them and provided financial support (Narodnoe obrazovanie, 1862: 40).

In most cases parish schools were under the management of teachers belonging to the largest religious group in the parish. If it was necessary to establish more than one school for different religious groups in the parish, one school was a responsibility of a teacher from one religious group, and another of a teacher from another group. The children of the parents who did not followed the same religion with a school teacher were permitted not to attend the Law of God lessons but they had to learn the rules of faith from a priest of their confession.

Parish schools taught the following subjects:

1. Law of God;
2. Reading;
3. Writing;
4. Linear Drawing;
5. Spelling and Grammar;
6. Arithmetic and Accounting;
7. Singing;
8. General Geography and Geography of Switzerland;
9. History of Switzerland;
10. Fundamentals of Natural Philosophy with its Practical Application;
11. Rhetoric Exercises;
12. Rules on the rights and duties of a citizen (Narodnoe obrazovanie, 1862: 40-41).

Parish schools were supervised in each canton by the Council of Inspectors or the General Council for Public Education, chaired by the Minister. The inspector was responsible for visiting all cantonal schools at least once a year and reporting to the government on the state of the schools, pupil progress, teaching methods, degree of control over diligent attendance of schools by children in each parish.

Besides this general council of inspectors, each community also had a private council of inspectors in place, elected annually from the clergy and the community's educated people; they, in turn, inspected parish schools, at least once a year and made all details on pupils' successes known to the Minister of Public Education.

Many cantons ran one teacher seminar to train teaching staff. By the 1860s, there had been 20 such seminars in Switzerland (15 for male teachers and 5 for female teachers) (Varentsov, 1863: 15). The study period was 2 or 3 years at a teacher seminar. There were cases when one canton was unable to cover the cost of operating such a seminar, and in this situation other cantons came to its help. The school regulations in each canton required that a teacher had a certificate of a standard form for the right to private tuition. Examinations for this certificate were carried out by the Central Council for Public Education. Those awarded the teacher's certificate received employment only based on competition, and, therefore, had to pass secondary exams. The secondary exams were carried out by the local school committee. At the exam, the teacher was expected to demonstrate not only the knowledge of the subject, but also their skills to transfer their knowledge to pupils (Narodnoe obrazovanie, 1862: 42).

Importantly, the idea of establishing teacher seminars in Switzerland was put forward for the first time already in the late eighteenth century. For example, a decree of 1798 on public education voiced the idea but for political reasons the initiative was shelved until better days. The law of May 28, 1806, ratified to open an institute for teachers, and even the operation regulations for the new institute were approved in 1811. Nevertheless, the initiative was never put into practice. On September 1, 1833, the first teacher's seminar was launched in Lausanne. A similar seminar for female teachers was set up on January 1, 1837. The training program at the men's seminar consisted of three years, and at the women's one – of two years.

Students were enrolled in teacher seminars once a year, before the start of educational courses. The Council for Public Education announced via newspapers the day of entrance examinations at least one month in advance. Applicants were to notify the seminar director in writing of their intention ten days prior to the examination. In addition to the application, the seminar entrant had to submit certificates of birth, rank and morality. Moreover, some cantons required to submit a medical certificate that the candidate did not have any contagious diseases and organic deficiencies.

On the appointed day, candidates underwent examinations. In the canton of Vaud, they were examined by a special commission of four experts appointed by the Council for Public Education, chaired by the seminar director. The exams were held in the following subjects: Reading, Spelling, Grammar, Arithmetic and Geography. In addition, the commission made sure that the candidate had a fine ear for music. After the examination is completed, the commission submits a report to the Council for Public Education with their opinion and comments on the abilities of each candidate.

The Council finally makes a decision on admission. Applicants had an opportunity to enter directly the second or third (senior) grade. Such admission only required to pass the exam on the subjects that were studied in previous years.

Here is a list of disciplines included in the training program for teacher seminars:

Law of God. The content was distributed across grades in the following way: the first year was devoted to the sacred history; the second one was a systematic course including dogmatic and moral theology; the third one covered the reading of books of the Old and New Testament with historical and geographical explanations. Each grade had three lessons per week. A similar curriculum was introduced for a women's seminar with the course sub-divided into two rather than three years.

French Language, 5 lessons per week, and the senior grade at the men's seminar had 4 lessons. The first year curriculum included the following: the Grammar course – General Principles of Language and Etymology; Logical and Grammatical Analysis, Spelling Course; Reading and Writing; the second year – Syntax, Grammatical Analysis, Compositions, Reading by Heart. The third year curriculum for the men's seminar comprised: a more detailed Syntax, Theory of Synonyms and Tropes, Recitation; Written and Oral Presentation of Ideas; Pedagogical Exercises.

Arithmetic. At the men's seminar, Arithmetic was taught four, three and three lessons per week per year correspondingly, at the women's one – four lessons in each year; in addition, at the men's seminar, they taught geometry two lessons in all three grades. In the first year, students learned how to conduct mathematical operations with integers, vulgar and decimal fractions, rule of three, mental calculations; in the second year – rules of relationship, mixing, percentages, bills discounting, rules of divisibility by 2, 3, etc., keeping accounting books; in addition, at the men's seminar: in the same year, general algebraic concepts; in the third year – raising to the power and square and cubic root generation, progressions, logarithms, various numbering systems, double-entry bookkeeping.

Geometry is taught only at the men's seminar: in the first year – Longimetry and Elements of Plane Geometry, in the second – End of Plane Geometry, in the third – Solid Geometry. This course studied Surveying and Plan Drawing.

Geography has three lessons per week; the Geography course was distributed as follows: at the women's seminar, in the first year – General Concepts of Mathematical and Physical Geography; in the second year – Political Geography of Europe and Major States in Other Parts of the World, Political Geography of Switzerland. At the men's seminar, in the first year – Physical Geography and Elements of Mathematical Geography; in the second year – End of Mathematical Geography and Political Geography of Europe and Roman Cantons of Switzerland; in the third year – Political Geography of Other Parts of the World and German Switzerland. All grades included lessons on drawing geographical maps.

History. History was taught two hours per week in each grade. Students at the women's seminar had only History of Switzerland: in the first year – the period before the Reformation, in the second year – period up to modern times; afterwards they studied the history of their canton. At the men's seminar, they studied Ancient and Medieval History in the first year; in the second year – Modern History followed by History of Switzerland before the Reformation; in the third year – End of History of Switzerland and the history of their canton.

The course of sciences was delivered three hours per week in the two first grades at the men's seminar, and two hours per week in the rest. The women's seminar offered Physics and Meteorology in the first year; Botany and Zoology – in the second year. In addition to these two courses, the men's seminars gave mineralogy, geology and chemistry in the third year (Varentsov, 1863: 26).

Pedagogy was taught starting from the second year. The women's seminar allocated for the course 4 hours per week; the training program was designed to explain general principles of upbringing, concepts of physical and moral upbringing; education; teaching arts and sciences; various teaching methods; school organization and management. At the men's seminar, this course was taught at the senior grade; it was preceded by Anthropology that was delivered twice a week in the second year. In addition, students at the men's seminar also received two Logic lessons twice per week at the end the last sixth semester.

Jurisprudence was delivered at two lessons per week in the last semester at the women's seminar; at the men's seminar – one lesson in the fifth semester and two lessons in the sixth one. The course outlined general notions of rights and obligations; conditions of public life, supreme power, laws, public guarantees, personal service, taxes; notions of the Constitution and historical development of Swiss constitutions; description of rights and obligations as defined by the latest effective Constitution.

Presentations on all the subjects were given both from a theoretical and from a practical point of view for various applications. Teachers' task was to test the knowledge of seminarians by asking many questions and give them pedagogical problems to solve, each in their own branch of teaching.

The women's seminar added housekeeping lessons to these subjects in the amount two hours per week in the senior grade. The course considered general housekeeping concepts; conditions of good housekeeping; nursing; house management, furniture, tableware, kitchenware and utensils, dress, linen, provisions: firewood, wine, vinegar, oil, candles, soap, tea, coffee, seasonings, flour, garden vegetables and various ways of cooking them.

The course of Music was broken up into theoretical and practical lessons; it included both church and secular music, but only one vocal sub-course that had five lessons per week at the first grade and four in further years.

The seminar curriculum also included calligraphy: it comprised various types of writing and handwriting, methods of dressing quills, holding them in hand and various methods and techniques of teaching. The number of lessons at the men's seminar was four, four and two; at the women's one – three and two.

Drawing was delivered in four, four and two lessons at the men's seminar, and at the women's one – two in each grade. These included: first year – drawing, second year – sample drawing, and final year – life drawing.

Gymnastics was allocated three hours per week at the men's seminar, and two hours at the women's seminar. Classes at the seminar could be combined for lessons in Music, Drawing, Calligraphy and Gymnastics. At the women's seminar, this also practiced for needlework lessons which were run 8 hours per week in the first grade and 6 hours in the senior grade.

The course at Lausanne seminars lasted from May 20 to April 20, divided into two semesters. In addition to holidays, the seminars were closed for two weeks after spring exams, for five weeks in the harvest time and for three weeks in the vintage period. The number of lessons per week was required not to exceed 42 in summer and 39 in winter; each lesson lasted 1 hour, and Drawing could take two consecutive hours. Lessons started at 7 a.m. in summer and at 8 in winter; after lunch studies lasted from 14 to 17 p.m., excluding Saturdays when there were no afternoon classes (Varentsov, 1863: 26).

The responsibility of managing seminars was placed on directors who were also supposed to teach students: the director had to deliver Pedagogy and Jurisprudence but not more than 14 hours per week. As part of their job duties, directors were expected to ensure the appropriate unification in methods and lines of teaching, the director gave each teacher a free hand in choosing techniques and practices. The director was present, where possible, in classrooms at lessons to make sure that the academic hours allocated by the program were actually devoted to the designated subject, as well as to form their own estimate of the teacher's skills and abilities, students' classes and their academic performance. At a number of seminars, directors were obliged to conduct practical classes, attend neighboring vocational schools and supervise internal processes and procedures.

In addition to the director, seminars employed a number of teachers and their assistants who were accountable to the director and followed their orders; taken all together, they constituted a pedagogical council that discussed relevant issues at monthly meetings; under special circumstances, the meetings could take place more often; meeting dates were proposed by the director or three teachers. The council developed a teaching plan, daily lesson schedule at the seminar, an extra-curriculum program and disciplinary rules; decided on the issues of imposing special corrective actions; on the dates and start of holidays, and also determined, at the director's proposal, what books, devices and training aids should be purchased. In addition, the director evaluated students based on their academic successes and behavior, formulated a proposal on the final admission and dismissal of seminarians and made decisions on all matters relating to the seminar.

All lessons were designed to achieve not only learning objectives but also educative goals. The progress of seminarians was assessed at annual examinations that determined whether the student was eligible for the next grade or stayed for the second year to repeat the same courses. At the end of the full course, the council set the date for an examination for the teacher's diploma. The event was public and was carried out by a commission chaired by a member of the Council for Public Education. The examination report was submitted to the Council for Public Education, which eventually issued diplomas. Candidates were qualified to receive the diploma provided they had only satisfactory marks.

However, it was not enough to have the diploma to get a teacher's position in a community school. The community, which was to open the appropriate vacancy, announced the competition terms in advance and provided a detailed description of the teacher's duties and salary. The competition could be entered either by those who had a teacher's diploma, or by those who was 23 years old and had at least 5 years of experience as an assistant teacher. After all official procedures were observed, the public exam began attended by experts. As soon as the exam ended, the commission chose a candidate by a simple majority. (Varentsov, 1863: 31).

5. Conclusion

Summing up the above points, we can say that the government turned its attention to talent training for primary schools almost as soon as primary education was introduced in Switzerland in the 1830s. Such training entirely fell on the so-called normal schools – seminars preparing teaching staff, which were divided into two types – men's and women's institutions. Although forms of teaching varied in different cantons in Switzerland, the federal government made considerable efforts to unify education in the country. On the other hand, in the context of competition with other cantons, sovereign cantons were committed to bringing only best practices into the system of public education.

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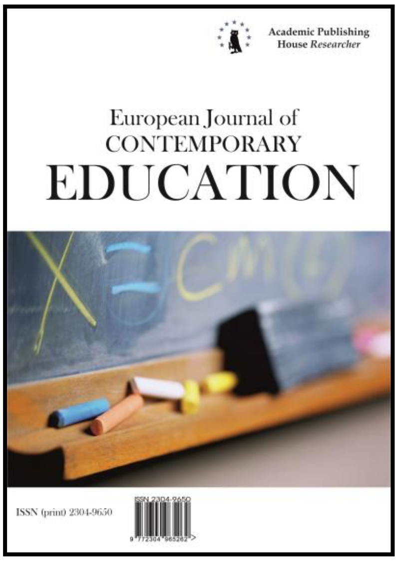

Education Reforms in the Don Region in 1880–1890 and Host Ataman Prince N.I. Svyatopolk-Mirsky

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Abstract

Ataman Nikolai Ivanovich Svyatopolk-Mirsky came under harsh criticism, targeted by his contemporaries from the liberal camp, as a persecutor of enlightenment who "has failed to completely abolish science, but not thanks to the lack of enthusiasm." On the other hand, today's historians urge the academic community to re-assess the figure of the ataman who contributed to opening several new educational institutions on the Don. In our paper, we tried to throw light on the situation by deliberately focusing on the policy of N.I. Svyatopolk-Mirsky in education. As a result, we found out that numerous close-downs of gymnasiums, initiated by the ataman, and reduced number of students can be explained not so much by political considerations but by criminal and educational reasons, and the process began after 1885, when a gymnasium principal fled Novocherkassk following an attack by his students. At the same time, instead of closed gymnasiums, N.I. Svyatopolk-Mirsky established technical and vocational schools that were long urgently needed. Our primary conclusion is that although N.I. Svyatopolk-Mirsky pursued a logical and reasonable educational policy in general, he made a number of mistakes – he excessively cut enrolment in gymnasiums and failed to provide the region with graduates from the network of vocational schools he created.

Keywords: education on the Don in 1880-1890, Don Cossacks, N.I. Svyatopolk-Mirsky, Novocherkassk gymnasium, ataman technical school, army trades schools.

1. Introduction

The history of education in pre-revolutionary Russia is currently attracting many researchers and provoking heated debates in academia. It is clear that the image of an illiterate and ignorant country, fostered in the Soviet era, does not reflect reality. For example, A.A. Cherkasov

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convincingly showed that by 1914, in the Russian Empire, 80 % of school-aged children had received education at public or private schools or at home (Cherkasov, 2011: 146-147). Meanwhile, it is becoming increasingly obvious that education in the great power was region-specific to a sufficient extent to explore the history of education separately in different regions (Khramtsov, 2018; Shevchenko et al., 2016). The Don Host Oblast was not an exception in this aspect, but works devoted to the education in the area are mixed and inconsistent. For example, A.A. Karpenko, continuing the typical line of the Soviet historiography, writes that most progressive teachers were persecuted the by reactionary authorities and government efforts to improve education had a forced nature (Karpenko, 2006: 229-256). Contrary to that opinion, L.A. Donskova insists that "the cooperation of the government and civil society on issues related to education in the Don region was very efficient" (Donskova, 2008: 138). From our viewpoint, we can succeed in addressing this contradiction if we change our research methodology by moving from the general works, describing long historical periods and seeking to deliver broad generalizations on the history of Don education, to the works covering more specific aspects, but strictly relying on a wider range of facts. In fact, both A. A. Karpenko, and L.A. Donskova had grounds for the conclusions they drew: over the long chronological period, reviewed in their papers, the situation in the educational system of the Don Host Oblast changed several times, and one of these shifts will be discussed in this work.

In 1860-1870, the Don education, as was the case in the rest of the Russian Empire, showed very rapid progression. A prominent Don statistician, S.F. Nomikosov, wrote about it as follows: "In 1830, there were 1,051 students in the region's educational institutions; in 1835 – 1,080; in 1840 – 1,492; in 1845 – 1,533; in 1850 – 1,798; in 1855 – 1,813; in 1860 – 2,183. Thus, in the first 30 years of the period we selected, the total number of students grew as much as twice plus in the region. On January 1, 1870, there were 13,256 students in total, i.e. their number increased 10-fold over one decade. Henceforth, the growth proceeded not so fast, and by January 1, 1880, the total number of students reached 22,370, i.e. it increased by 69 % in 10 years (Nomikosov, 1884: 575). However, in 1881, a new Don Ataman was appointed. It was Prince N.I. Svyatopolk-Mirsky. Contemporaries of the liberal camp described him as being almost a caricatural persecutor of enlightenment, comparing him with the characters of M.E. Saltykov-Shchedrin. This is what cadet A.I. Petrovsky wrote on this in his social and political essays using rather a florid language: "Guided by the example of the third (after Derzhimorda and Ugryum-Burcheev) administrator (this is about Saltykov-Shchedrin's Town Governor Perekhvat Zalikhvatsky), but having significantly surpassed him in the scale of his destructive reach, Mirsky has closed (not burned, however, as Perekhvat Zalikhvatsky did) not one but several gymnasiums on the Don, and although has failed to completely abolish science (as this was accomplished by Perekhvat), but not thanks to the lack of enthusiasm" (Petrovskii, 1916: 23). Less emotion, but not less criticism, concerning the fight against enlightenment, which allegedly was waged on the Don in the years of N.I. Svyatopolk-Mirsky's administration, was expressed in the words of one of the most respected Don historians and local lore experts of the second half of the nineteenth century, A.A. Karasev: "The administration of Prince Svyatopolk-Mirsky (unknown as it may be, however, on whose initiative) has closed: Ust-Medveditskaya classical gymnasium as well as similar pro-gymnasiums in the stanitsas (villages) of Nizhne-Chirskaya and Kamenskaya, as well as parallel classes at the Novocherkassk classical gymnasium, as a result the total number of students in the latter has reduced from more than 700 to less than 300 people" (Karasev, 1899: 113). So, indeed, gymnasium education on the Don was almost completely eliminated under N.I. Svyatopolk-Mirsky, which brought him notoriety among pre-revolutionary historians of the liberal camp.

However, modern historiography exhibits signs indicating rehabilitation of the personality of N.I. Svyatopolk-Mirsky. The process was started by R.G. Tikidjian, who published an article on the Don Ataman. Here, the modern historian, while accepting the fact that "the prince did not encourage the growth of classical education", at the same time proved that the years of his character's administration witnessed "serious improvement in the primary general education of Cossacks" (Tikidzh'yan, 1998). Later A.A. Volvenko also called on historians to look more carefully not only into the negative, but also into the positive aspects of N.I. Svyatopolk-Mirsky's work in education: for example, it was under him that the Don Cadet Corps and the Ataman Technical School were established (Volvenko, 2017: 119-120).

We believe that the history of education on the Don in the time of N.I. Svyatopolk-Mirsky's administration deserves an individual study. The policy adopted by the Ataman really gives reason to consider him a character with a virtually grotesque caricatural nature, in the spirit of the heroes of M.E. Saltykov-Shchedrin or Soviet propaganda. On the other hand, other elements of this policy allow us to view him as the founder of vocational technical and handicraft education in the Don Host Oblast. In our opinion, N.I. Svyatopolk-Mirsky struggled to rebuild the educational system in the region, entrusted to him, to make it as efficient and contextualized in the then epoch as possible. However, he was not to succeed in his endeavor, and instead of a holistic system, actually created by the Ataman, historians usually see only its separate parts, and this fragmentized approach makes them take such a disagreeable position towards N.I. Svyatopolk-Mirsky. So, what developments actually took place in the Don education over his administration? We will try to answer this question in our paper.

2. Materials and methods

The resignation of N.I. Svyatopolk-Mirsky from the post of Don Ataman in 1898 was a controversial event. Shortly before this, the Don nobility submitted Nicholas II a complaint that Cossacks quickly slid into poverty, and petitioned to create a special commission to investigate the causes of this impoverishment (GARO. F. 410. Op. 1. D. 682. L. 1-60b). Although there is no direct evidence that this event and the subsequent transfer of N.I. Svyatopolk-Mirsky to the State Council are connected, the outcome was the formation in 1899 of "His Imperial Majesty's Commission to analyze the causes that damaged the economic life of the Don Host, and to formulate measures to restore its economic well-being" or "N.A. Maslakovets' Commission" was unsympathetic towards the policy of the former Ataman, who, on top of it, died late in 1898. As the meetings of the commission was paid serious attention to education, its proceedings (Protokoly..., 1899), and the final report (Maslakovets, 1899) are essential sources of information on the subject under review. The book by I. Artinsky "Essay on the history of the Novocherkassk military gymnasium" is also of great interest. Its author used the now lost materials from the gymnasium archive as a basis to create a picture of the real situation in the vital educational institution on the Don (Artinskii, 1907). In addition, we will turn to the memorandum of retired Colonel A.G. Fatyanov, which contain information on another gymnasium located in the Ust-Medveditskaya stanitsa and is stored in the State Archive of the Rostov Region (GARO) (GARO. F. 46. Op. 1. D. 3282).

As for the methods we employ, given the little known facts we will cover here, we will widely utilize the historical descriptive method. The historical comparative method will help us see whether the educational reforms, implemented by N.I. Svyatopolk-Mirsky, were efficient or not, and the system method will facilitate an understanding of main ideas at the heart of the Ataman's educational policy.

3. Discussion

As it was shown, N.I. Svyatopolk-Mirsky is usually blamed for closing most Don gymnasiums and pro-gymnasiums in the first place, as well as for a dramatically decreased number of students in the last surviving Novocherkassk gymnasium. Although we acknowledge that the decisions were unwise in the long term (we will elaborate on the aspect below), we cannot but point out the facts that drove the Ataman to tough choices.

The Novocherkassk gymnasium was a central role model educational institution in its category for the entire Don Host was. However, the time between the end of 1870 and beginning of 1880 is the least successful period for this school. The gymnasium's historiographer, I. Artinsky, went negative in his description, laying gloomy colors on with a trowel. "Students were moved up to the next form in a peculiar way: the promotion was granted not only to the ones with 2½ and 2¼ grade on one or two main disciplines, but even to those with absolute two grade (for example, on mathematics, geography, Latin, French and German), without an appropriate exam after the summer break" (Artinskii, 1907: 286). "The student laxity reached the point where some of 7 or 6 form students performed natural organic functions in the corridor and in the classroom without hesitation" (Artinskii, 1907: 291). However, I. Artinsky more often simply cited excerpts from the reports of gymnasium principals, which were all too eloquent. For example, a gymnasium principal in 1878-1880, I.V. Kansky complained that students completely lacked "assiduity, a skill to the diligent work without interruptions" (Artinskii, 1907: 284). His successor V.Yu. Khoroshevsky (1880-1883) bluntly wrote to his management that "impeccable discipline and good manners are very difficult to instill into the students of the Novocherkassk gymnasium, who in the vast majority belong to families that have almost no pedagogical influence on children" (Artinskii, 1907: 290). Moreover, the situation seemed to aggravate over time, and the next director, D.F. Shcheglov (1883-1885), provided a totally pitiful picture: "An assistant class tutor who was told by an attendant that fourth-grade students smoked in a toilet room, and who wanted to go there to stop the students, was grabbed by the sleeve by one of the students who kept him in front of the toilet room until the students who smoked, warned by the cry of this student, did not stop smoking. Two teachers received anonymous letters threatening that they would be killed if they continued to give students bad marks" (Artinskii, 1907: 291).

The situation went far beyond the normal bad behavior of gymnasium students. I. Artinsky attributed this to the fact that gymnasium inspector M.K. Kalmykov not only defended the culprits, but also provoked them to act against measures designed to establish discipline (Artinskii, 1907: 292-293). Moreover, such measures failed to enlist support from society and among teachers themselves, and as a result gymnasium principals were simply driven out, most often through planned press campaigns (Artinskii, 1907: 284-293). In this context, the student performance also predictably dropped: in some classes, the percentage of underachieving students reached 70 % (Artinskii, 1907: 291)!

And principals of the Novocherkassk gymnasium cannot be blamed for whipping up tension. Quite the contrary: until 1885, they were able to put into practice only weak half-measures. For example, already V.Yu. Khoroshevsky began to complain about the "too big population of the gymnasium", which undermined any attempts to restore order, but under his management the number of classes and students continued to grow, and only D.F. Shcheglov succeeded, despite major objections from the pedagogical council, in accomplishing first close-down actions in parallel classes, and at the moment it was only about preparatory classes (Artinskii, 1907: 289-290). D.F. Shcheglov also tried to introduced a system to spy on students, however, he admitted that this "cause was very challenging and almost pointless" (Artinskii, 1907: 292). Meanwhile, introducing such a spying practice was required not only for political reasons: it accidentally became clear that gymnasium students were regular visitors at brothels, and one of them stole things on a systematic basis (Artinskii, 1907: 292). The end of this story is in some sense indicative of Russia of the 1880s, as a group of students attempted to blow up a principal's apartment and the gymnasium building itself, and, surprisingly, the public saw it that it was D.F. Shcheglov who was responsible for the situation. After the explosion, D.F. Shcheglov began to fear for his life and in the end actually fled Novocherkassk (Artinskii, 1907: 292).

In this environment, D.F. Shcheglov's successor, A.P. Pyatnitsky (1885-1893), secured support of other officials at the Ministry of Public Education and local authorities. Already in 1886, the initiative of the Kharkov school district facilitated the adoption of the following resolution: "Students at each secondary school in the Novocherkassk city outside the walls of the institution shall be supervised by persons of the teaching staff of all educational institutions" (Artinskii, 1907: 294). Based on this, teachers were now obliged to monitor not only their own, but also other teachers' students, and they were given special identification cards, and had to arrange special duties in the most visited places (for example, in Aleksandrovsky Sad and on Moskovskaya Street) they (Artinskii, 1907: 294-295). However, N.I. Svyatopolk-Mirsky, perhaps impressed by an attempt to blow up the gymnasium principal, was not content with this decision and additionally commissioned the local police to control both students and teachers. Its responsibility was to communicate any violations committed by students at an education institution to the head of this institution, as well as "ensure" that teachers fulfill the "right and duty to supervise the behavior" of students (Artinskii, 1907: 295). Meanwhile, N.I. Svyatopolk-Mirsky personally, according to accounts by I. Artinsky, insisted on the "aristocratization of the Don education". It meant restricted access to secondary schools for the majority of the population, even from Cossacks, due to drastically reduced enrollment targets (Artinskii, 1907: 296).

The historiographer of the Novocherkassk gymnasium (by the way, a priest in his primary profession) expressly showed negative attitude to the measures taken by the Ataman, specifically emphasizing the fact that from 1885 to 1892 the number of students went down in the gymnasium from 534 to 225, i.e. more than half of all parallel classes were closed (Artinskii, 1907: 299). It is meaningful that he provides a very glossy and concise record of the events after 1885, especially as compared with the highly detailed descriptions of previous years, referring to the fact that "for reasons that are quite understandable, we have to present this period of the gymnasium's life only in a brief manner and in very general terms" (Artinskii, 1907: 298). However, I. Artinsky concentrates on the fact that by 1906 the authorities still had to restore parallel classes, and the gymnasium had 543 students "in the days of old" (Artinskii, 1907: 300).

The situation with the Don gymnasiums after 1885 can be suggested by the documents of the local gendarme department, which were published in the Soviet time with a purpose to denounce the tsarist government. In 1888, the head of this department, Colonel Strakhov, reported to superior officers the following: "No proper supervision was exercised for these (those studying in the Don gymnasiums) youth, their tutors included persons of immoral and dubious political views. As a consequence, all these institutions, especially the district gymnasiums in the stanitsas of Ust-Medveditskaya and Nizhne-Chirskaya, were hotbeds of harmful ideas and revolutionary centers. The dissoluteness of youth knew no limit. <…>. But over the next two years, all these outrages were brought to an end. The district gymnasiums in Nizhne-Chirskaya and Ust-Medveditskaya have been closed down, and the rest have stopped admitting students whose status and upbringing do not comply with the goals of secondary education. The inspection department has been set in proper order, the senior officer and teaching staff has been totally replaced. Instead of the closed district gymnasiums, a technical school and a trades school are opened in Novocherkassk. Both of these institutions enjoy the special attention of Prince Svyatopolk-Mirsky and are managed with outstanding excellence" (Nash krai, 1963: 469). As it becomes clear after reviewing the facts given by I. Artinsky (who was never a supporter of N.I. Svyatopolk-Mirsky), this gendarme report does not at all imply the cruelty of the local authorities towards Don education in 1880, as the Soviet historiography tried to show. Until 1885, the education quality, even at the model Novocherkassk gymnasium, was extremely poor due to the lack of discipline – students threatened teachers and tried to kill the principal, and only with the introduction of the most stringent measures, the authorities managed to stabilize the situation. By the way, these measures were implemented not in 1881, with the start of counter-reforms in Russia, but following a certain event, the flight of gymnasium principal D.F. Shcheglov from Novocherkassk in 1885, who feared for his life. It is the standpoint taken by I. Artinsky on this issue which we view as the most balanced one: the priest sympathized with the principals of the Novocherkassk gymnasium and considered establishing order at the facility as a crucial step, but he condemned the most odious government decisions, such as police control of teachers or reduced numbers of students by 50 %.

However, the last decision taken by N.I. Svyatopolk-Mirsky was also grounded on significant facts. As we can see from the above gendarme report, a technical school and a trades school were launched on the Don instead of the closed gymnasiums. Of course, one can try to interpret these steps as efforts of a reactionary ataman to eradicate classical education. But a different vision seems more reasonable to us. The point is that by the 1880s the Don Host Oblast simply could not offer sufficient opportunities for numerous graduates of local gymnasiums, while it urgently needed specialist practitioners in many professions. We discovered a memorandum of a retired colonel A.G. Fateev, written in 1898 and stored in the State Archive of the Rostov Region. We are not so much interested in the key objective of the memorandum (to drive the work of N.A. Maslakovets' Commission in a specific direction), as in some facts provided in it concerning the Ust-Medveditskaya gymnasium. A.G. Fateev wrote: "The experience of the former Ust-Medveditskaya gymnasium, which existed more than 3 decades, illustrated that even among the graduates of this school, who later received a higher education, more than half do not see service in the Don Host, despite their willingness and efforts to devote their capabilities to the benefit of their home land. For example, let us give the names of former students at the Ust-Medveditskaya gymnasium in the number of 41 people, specified in the list enclosed hereto, with the description of their qualifications and locations. (The entire list was compiled using private information and, of course, is not in the least exhaustive, and moreover, it covers the time period from 1872 until the closing of the gymnasium in 1895). Of those with university education, who were alumni of the same gymnasium and serve in some position in the Host, there were about 10 doctors and as many lawyers and that is all" (GARO. F. 46. Op. 1. D. 3282. L. 15-15ob). Thus, the graduates of this educational institution, who achieved the most notable success, preferred to develop their careers outside the Don Host Oblast. A similar situation, according to I. Artinsky, evolved in the Novocherkassk gymnasium (Artinsky, 1907: 305-306). In principle, a situation where graduates of Don gymnasiums built their careers in other provinces, was not bad in itself, especially as A.G. Fateev noted: "Instead, people with a university degree from other provinces and the Kingdom of Poland are assigned for service in the Don Host Oblast" (GARO. F. 46. Op. 1. D. 3282. L. 15ob). And yet N.I. Svyatopolk-Mirsky's decision not to open new gymnasiums instead of the closed ones, but establish vocational schools that could train professional needed by the Don, was quite logical.

Moreover, the two schools organized in Novocherkassk was only a starting point to in an initiative to create a complete network of vocational educational institutions in the Don: in 1890, the Ataman succeeded in the opening of another 5 army trades schools in districts, with a mission to "promote the knowledge of crafts among Don Cossacks, required to make articles of clothing and equipment for Cossacks joining the service" (Protokoly, 1899: 253). As a result, by the end of the nineteenth century, 21 vocational technical and craft institutions operated on the Don: the Ataman Technical School, 6 army trades schools and 14 trades departments at district vocational schools (Protokoly..., 1899: 252). These delivered training to about 600 Cossacks, and liberal members of N.A. Maslakovets' commission, who were quite critical of the Ataman who had already been removed from the position, passed the following verdict against the vocational school system, created by him: "Although the number of trades schools is not large, one cannot nevertheless consider that the number of their students belonging to the military estate is also insignificant, if only to define such an organization for the area as to contribute to the use of the knowledge obtained for local demand" (Protokoly..., 1899: 252).

The need to create a network of vocational schools in the Don region was debated since at least 1860, but only when N.I. Svyatopolk-Mirsky did implement real measures in this area. Don scholars and public figures not so much insisted on technical schools but on the much needed agricultural training facilities. For example, a prominent statistician, N.I. Krasnov argued in 1863 that "it is only through improvements of education levels and early introduction into the basics of farming from school days that we can inspire Cossacks to accept better methods of agronomy; neither the example of landowners, nor huge profits received by tenant merchants have been able so far to change the farming system used by Cossacks" (Krasnov, 1863: 250). An even more definite opinion on this issue was expressed by a fellow statistician S.F. Nomikosov: "Providing arrangements for issuing cheap credits to farmers and opening several agricultural schools presents no particular difficulty. <...>. Schools are an essential need judging from the backwardness of the masses, and this means that even if the people invent more rational agricultural methods themselves, the process will perhaps take a very long period of time. The masses need an example, and an example can only be given by a school or a farm with agricultural methods designed specifically for small homesteads" (Nomikosov, 1884: 729). S.F. Nomikosov, however, also defended the need to create vocational schools as well, despite the fact that this initiative would imply serious spending from the government: "The entire issue related to vocational schools can be reduced to the following: are there sufficient funds available to open such schools? If the funds are available, the question of costly maintenance is an idle question; if funds are not available, idle is the very question of opening schools" (Nomikosov, 1884: 738). Interestingly, this scholar, who had connections with N.I. Svyatopolk-Mirsky (his major work, "The Statistical Description of the Don Host Oblast", as the cover read, was published by the order of the Ataman), just advocated the need to expand vocational rather than general education among Cossacks: "Supporters of general education can say that it is better to have three public schools than one vocational facility, but we think just the opposite, for it is better to have one artisan, or some kind of handicraftsman, than three scribes who have no idea where to use their school knowledge" (Nomikosov, 1884: 738). Therefore, the valid grounds behind N.I. Svyatopolk-Mirsky's idea are beyond doubt, and even his liberal opponents agreed that the Don Host Oblast was short of craftsmen. However, difficulties were connected with implementation, and we will turn to specific examples to confirm the statement.

The intention to launch the higher institution of the newly created vocational schools – the Ataman Technical School – crystallized already in in 1872, long before N.I. Svyatopolk-Mirsky came to the Don. In Novocherkassk, at that time a fund-raising campaign was even rolled out to set up a similar educational institution, of which the city felt "a pressing need", and the Oblast government and the zemstvo administration (zemstvo – an elective council responsible for the local administration of a provincial district in czarist Russia) promised their support (Kratkie svedeniya..., 1895: 3). Unfortunately, the collected sum was insufficient, and in 1881 it was even decided to shelf the technical school plan for an indefinite period. The project was bailed out only thanks to the personal involvement of N.I. Svyatopolk-Mirsky in 1882, who resumed work on it and secured guaranteed financing from the government to build the proposed educational institution (Kratkie svedeniya…, 1895: 4). The school book, which came out in Novocherkassk in 1895, even announced the incumbent Ataman a major creator of the school, which obviously did not correspond to reality. The active construction phase started only after the death of Lieutenant Colonel Dyakov in 1885, who bequeathed his considerable fortune "to the establishment and reasonable maintenance of a technical school" (please, note the curious fact where N.I. Svyatopolk-Mirsky was credited with others' merits) (Kratkie svedeniya…, 1895: 4). Still, the role of N.I. Svyatopolk-Mirsky in creating the new educational institution cannot be underestimated, although it was not always positive: for example, on his initiative the physical classrooms of the two abolished gymnasiums were handed over to the vocational school (Kratkie svedeniya…, 1895: 7). The Ataman was an honorary trustee of the vocational school and personally chaired the meetings of the board of trustees. Therefore, it is the Ataman Technical school that we can consider an example of what he sought to receive education (Kratkie svedeniya…, 1895: 7-8).

As an organization, the Ataman Technical School was a lower mechanics and engineering school, but for two important exceptions. First, contrary to the accusations against N.I. Svyatopolk-Mirsky of the fight against democratized education, he simplified the access to the school: at similar educational facilities of the Russian Empire, applicants were required to submit course completion certificates from two-year rural schools, while everyone, who during a special test of knowledge demonstrated that their level was consistent with the course of such schools, even if the applicant had never attended any institution, was accepted to the Ataman Technical School (Kratkie svedeniya…, 1895: 8). Secondly, the course was extended from 3 to 4 years, but the 4 year was exclusively allocated for practical training, so that graduates could develop the skills acquired during the basic course (Kratkie svedeniya…, 1895: 8). Hence, the new school was also accessible to the Cossacks from distant stanitsas, who prepared for the exam themselves, and those who graduated from it were supposed to excel competitors from similar schools in their proficiency level.

And indeed, education at the Ataman Technical School proved to be very relevant for the South Russian labor market. The above book of 1895 about the school contains a list of its graduates, and it shows that many of them earned 600, 900 and even 1,200 rubles a year (Kratkie svedeniya…, 1895: 59-60). For comparison, a Don public figure, V.Ya. Biryukov, estimated that the annual income of an average Cossack family in the Khopersky district, consisting of 8 people, both males and females, including 2 adult male workers, amounted to 158 rubles 50 kopecks, and all the property of such a family to 897 rubles. (Protokoly, 1899: 116-117). However, the stumbling-block was that, as it was the case with gymnasiums, the most successful graduates of the Ataman Technical School continued their professional development outside the Don Host Oblast or in non-Cossack Taganrog and Rostov-on-Don, while Novocherkassk, let alone stanitsas, received few benefits from the newly opened school. In addition, graduates of the school often joined the Host shortly after finishing their studies, and there they could not apply their talents. More detailed statistics looks like this: in 1892, first 20 graduates left the ataman school, of which as of 1895 there was no information about 1, 2 died, 6 were on the military service, 1 returned to his stanitsa to help his father with household chores, 2 worked in Novorossiysk, 4 in Rostov-on-Don and only 4 in Novocherkassk (Kratkie svedeniya…, 1895: 58-60); the second wave of graduates (1893) was slightly smaller, it numbered 13 people, of whom as of 1895 there was no information about 1, 3 were on the military service, 1 returned to his stanitsa to help his father with household chores, 2 worked in Novorossiysk, 2 in Taganrog, 2 on the railways (1 of them outside the Oblast), 1 in Bryansk and only 1 in Novocherkassk (Kratkie svedeniya…, 1895: 60-61); finally, the third wave of graduates consisting of 13 people left the school in 1894, and as of 1895 there was no information about 2, 2 were on the military service, 1 continued training outside the Oblast, 4 worked in Rostov-on-Don, 1 on the railways and 3 in Novocherkassk (Kratkie svedeniya…, 1895: 61-62) (some plants on the list had no location specified, and so we proceeded from the fact that if in one case the list refers to the "Glebov plant" in Rostov-on-Don, other cases refer to the Rostov-on-Don Glebov plant, while the plants without locations operated in Novocherkassk). It is clear from the above that less than a quarter of graduates of the Ataman Technical School remained to put the acquired skills for the good of Cossack districts in the Don Host Oblast. The situation could have become somewhat better over time thanks to those who returned to the Host, but some of them managed to find profitable positions outside their home stanitsas and Novocherkassk prior to the conscription:

for example, Vasily Alekseev found work in Armavir, earning 50 rubles a month (Kratkie svedeniya..., 1895: 58).

The outcome of opening army trades schools was even less satisfactory. Here is what the officer of the Host Staff, A.I. Ulyanov wrote about them in 1899: "With these schools established on the Don, every military district set a goal to provide the Don population with professionals who learned several types of crafts and could with greater success and at cheaper prices make various articles of clothing and equipment for Cossacks liable for military service, but in fact it has become clear that the existing program of drill sessions and general educational curriculum for students at these schools takes a lot of time at the expense of deeper training of practical crafts and better ability to accept various external orders, mainly articles of equipment for young Cossacks, and as a result, the schools are now producing many Cossacks prepared for entering the cadet school or for clerical jobs in these units, rather than for artisanship for these units" (Protokoly..., 1899: 256). The officer worked in the Host administration and toned down his account rather than exaggerated the situation: the final report of N.A. Maslakovets' commission included very discouraging figures. According to them, out of 542 Cossacks who graduated from army trades schools between 1890 and 1898, only 32 opened their own workshops and 84 became workers at other masters, i.e. only 21 % of graduates were truly engaged in the profession they were trained (Maslakovets, 1899: 104). 22 % never made use of the acquired skills, and the majority, the remaining 57 %, either utilized the knowledge sporadically, for extra earnings, or did their military service (Maslakovets, 1899: 104).

Already A.I. Ulyanov attributed the failure of the initiative to put army trades schools into normal operation to the wrong purpose set for him by N.I. Svyatopolk-Mirsky. The curriculum for the schools, approved personally by the Ataman, planned to train army artisans who would then supply Cossacks with required accoutrements (Protokoly..., 1899: 253-254). Accordingly, it was expected that the Cossacks who graduated from the course would be assigned to the first stage regiments (where Cossacks did first four years of the 12-year term in the Host) as craftsmen but not as combatants. At the same time, the graduation standard numbers were not correlated with the actual demand experienced by Cossack units: the latter hardly exceeded 73 people a year, while vocational schools provided 107 professionals each year (Protokoly..., 1899: 255). To make things worse, even of these 73 craftsmen, actually needed by the Host, part served outside the staff, receiving much smaller salaries, and a request to revise the staff organization sent from the Don as early as in 1889, remained unanswered for an entire decade (Protokoly..., 1899: 255)! However, the project supposed that graduates of army trades schools would work in the Host, but as there were no vacant positions for all, some returned home "without having adequate skills in crafts to independently compete with local artisans, even in the context of modest needs of a stanitsa" (Protokoly..., 1899: 252). At the same time, specialists in the crafts that Cossacks needed in their domestic activities were not trained at army trades schools at all. Following this line, A.I. Ulyanov proposed reducing the number of the vocational schools to 4, but drastically expanding the number of occupations they offered by introducing civilian professions, as well as by cutting drill training and general disciplines and giving graduates more hands-on knowledge so that they could compete with stanitsa craftsmen (Protokoly..., 1899: 256). N.A. Maslakovets' commission also pointed out that it was absurd to appoint graduates of the vocational schools as lower-rank drill soldiers in active units: "Having served for four years in the ranks, the latter grow completely out of the habit of handicraft labor, and, upon return from the army, they look for work at home or elsewhere in another field" (Maslakovets, 1899: 104). The commission members also offered to reform the system of the army trades schools but they went to even greater extremes than A.I. Ulyanov. They offered to leave only 2 facilities, and the rest should not be closed but transformed into civilian vocational schools designed to train craftsmen relevant to stanitsas. These craftsmen should be granted the right to pay off the military service (Maslakovets, 1899: 105). Summarizing the episode with the army trades schools, we would like to give the most illuminative quotation about them, whose author was N.A. Maslakovets himself: "The army trades schools, operating in the Host as institutions with highly specific craft training limited to making articles of soldier uniforms and equipment for purely military purposes, exceed the corresponding demand; in the sense of meeting the needs of the Don Host to improve technical knowledge and appropriate craft training facilities for the Cossack population, they fail to achieve the desired goal" (Maslakovets, 1899: 104).

As a result, the best performance was demonstrated by the most unpretentious educational institutions of the vocational training network created by N.I. Svyatopolk-Mirsky. These were the craft departments at district vocational schools. Unfortunately, it is because of their unpretentious profile and efficient work, only limited information on them survived to this day. So, we will use the words of another member in N.A. Maslakovets' commission, a representative of the Oblast Zemstvo Committee, A.S. Yezhov. "The craft departments teach wheel joinery, smithcraft and metalworking, in the amount needed by the local population, and those who complete the course, do not lose in most cases their connection with family trades, and if they are naturally talented and fairly well-trained, they gradually become independent artisans, or they are engaged in the profession in their free time from farm work, and, despite the meager funds spent on these departments – 350 rubles per year – their value is lost (judging from the context, it is a misprint here. It should read "significant") among the population, so it now only remains to support the departments and facilitate the training activity through somewhat greater spending and no further patronage is required for the schools" (Protokoly…, 1899: 252). The commission's final report was somewhat more critical of the craft departments, but the criticism was reduced to the statement of the same fact that "the requirement of the universal army conscription for Cossacks poses the same difficulty in maintaining the willingness among those who received craft training to carry on professional activities after military service, as it was noted by us in relation to students of army trades schools" (Maslakovets, 1899: 104). However, with respect to the quality of training at the craft departments and the choice of specialties at them the rest of the commission members agreed with A.S. Yezhov: "Due to the fact that the craft departments at public vocational schools teach students crafts, most needed in the household of a Cossack, the number of people who, having received basic training in the crafts at public vocational schools, continue with it either in their own homesteads, or in workshops of other craftsmen" (Maslakovets, 1899: 104).

4. Conclusion

In 1898, A.G. Fateev that we have mentioned above wrote: "No higher educational institutions are available in the Oblast (Don Host Oblast) to satisfy the intellectual needs of the population. Of the secondary educational institutions we have: one classical gymnasium in Novocherkassk with 277 students (figures taken from the teacher's calendar for 1897) and three real schools: in Novocherkassk with 192 students, in Uryupin with 207 students and in Ust-Medveditsa with 78 students. <…>. For comparison, let us take the number of secondary general education facilities in neighboring governorates, without taking into account secondary vocational institutions, namely: Voronezh governorate – 1 classical gymnasium, 3 pro-gymnasiums and 1 real school; Kharkov governorate – 5 classical gymnasiums, 2 pro-gymnasiums and 3 real schools; Yekaterinoslav governorate – 4 classical gymnasiums, 1 real school; Astrakhan governorate – 2 classical gymnasiums and 1 real school and Saratov governorate – 3 classical gymnasiums and 3 real schools. So, our vast Don Oblast with its population is far more impoverished than our neighbors in terms of general education" (GARO. F. 46. Op. 1. D. 3282. L. 14-14ob). Indeed, this representation had full resemblance to reality, and the development of secondary general education in the Don Host Oblast, which had never showed great performance in the area, marked a backsliding in the time of N.I. Svyatopolk-Mirsky's administration: If the Don gymnasiums taught 1,059 people in 1881 (Nomikosov, 1884: 577), by 1895 the only surviving gymnasium retained 225 students! Moreover, students of the gymnasium, when they visited public places, were officially watched by teachers and police, the local gendarme department specifically focused on remedying their discipline, and the Host authorities complicated access to classical education for people "by their status and upbringing not compliant with the goals of secondary education". At the first glance at the history of the Don secondary education, one can easily agree with the conclusion suggested by pre-revolutionary liberal researchers, namely to the conclusion that N.I. Svyatopolk-Mirsky was almost a caricatural reactionary and could become a character in M.Ye. Saltykov-Shchedrin's works.

However, the reality, as usual, turned out to be much more complex. We found out that by 1885, when the Host authorities and gendarme department mounted their attack at the Don gymnasiums, the level of education at the facilities was very low (in some classes, the number of underperformers reached 70 %!), and the student behavior did not correspond even the same liberal requirements. Eventually, the intervention of the authorities followed not after the launch of counter-reforms in Russia, but after the students attempted to blow up the gymnasium and kill the principal who in the end fled Novocherkassk. On the other hand, it is the great number of the students that hindered any steps to restore order among them, and a certain reduction in gymnasium enrollment reasonably suggested itself. Of course, one can discuss the excessive rigidity of N.I. Svyatopolk-Mirsky's measures aimed at the Don gymnasiums, as well as the fact that after the Ataman was removed from the positions, the previous number of students was gradually restored. However, these measures were dictated by the circumstances and were a logical and consistent reaction to them.

In addition, the same A.G. Fateev wrote: "The initiative of His Grace former Host Ataman Svyatopolk-Mirsky established trades schools in each district, whose operation required significant sums spent by the Host. Without denying the usefulness of these schools, but considering the popular demand, we cannot but admit that the number of the existing facilities is excessive" (GARO. F. 46. Op. 1. D. 3282. L. 18). N.I. Svyatopolk-Mirsky not simply closed the gymnasiums, but set up vocational educational institutions instead of them, and by the end of his administration a network of such facilities was extended to cover the entire Don Host Oblast. The need for Cossacks to acquire specialist technical and craft knowledge was long overdue, and even political opponents of the Ataman did not deny the expediency of the vocational schools he opened. Their number reached 21. In fact, the Ataman built a unique education system on the Don, different from the rest of Russia, which was supposed to give Cossacks not so much general as practical knowledge. Perhaps he was guided by the words of a statistician, close to him, S.F. Nomikosov, who argued that "it is better to have one artisan, or some kind of handicraftsman, than three scribes who have no idea where to use their school knowledge". The best graduates of the Ataman Technical School, created by N.I. Svyatopolk-Mirsky, actually confirmed this idea with earnings of up to 1,200 rubles a year.

However, the system of vocational educational institutions established in 1880-1890 was not fully in line with the needs of the Don region. Perhaps another reason, why N.I. Svyatopolk-Mirsky closed the gymnasiums, was the fact that their best graduates later worked outside the Cossack territories of the Don Host, but the students of the Ataman Technical School did the same. As for the army trades schools, these were really oversupplied, and the training provided at them was too technical. As a result, only 21 % of their graduates chose to work solely in their specialty. Finally, the craft departments at the district vocational schools received totally inadequate funding to fully unlock their potential. And in the end, the network of vocational schools, created by N.I. Svyatopolk-Mirsky, was not entirely useless for the Don, but was unable to replace the network of the gymnasiums that he eliminated and that was gradually rebuilt after the death of the Ataman.

Therefore, in fact N.I. Svyatopolk-Mirsky proceeded from quite practical and consistent logic – undoubtedly conservative as it was – in his educational reforms, and the question whether his reforms did harm or offered benefits to the region is a worthy subject for a separate study. Of course, reducing the number of gymnasiums was not a right step, but the network of technical and army trades schools established instead compensated this error of the Don Ataman. Thus, we can understand the educational policy of N.I. Svyatopolk-Mirsky only if we adopt a comprehensive approach, because its positive aspects were inextricably linked with negative ones, and without closing the gymnasiums, it would have been impossible to open so many vocational schools on the Don.

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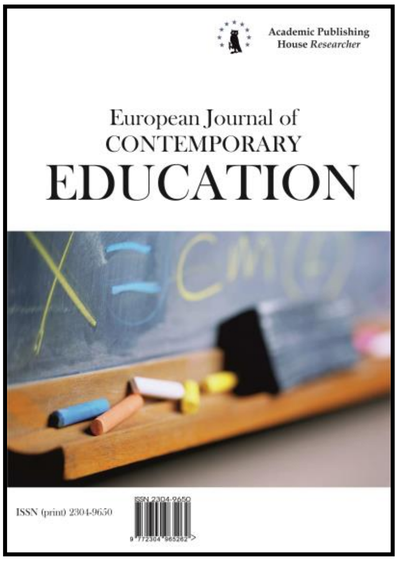

The Potential of Museums in the Mediation of Science and Technology. Museum Presentation and Education on the Example of the Technical Museum in Brno (Czech Republic)

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Abstract

This study examines museum presentations and educational activities in the area of technical museology, on the example of the Technical Museum in Brno (Czech Republic). Technical museology counts among the most popular segments of museum culture employed, in particular, in the popularization of science and technology. Through their exhibition activities, as well as museum and educational activities, museums approach target groups of visitors including pupils and students from all types of schools. Museums of technology have documented and mediated the progress in technology in society for nearly 200 years through a wide range of activities, especially in the form of the visualization of technological procedures of production, from the processing of a material to a finished product.

This contribution analyses and assesses the basic presentation, educational and scientific activities of the Technical Museum in Brno. It conveys the manners of its communication with the public, as well as the particularities of technical museology.

Keywords: technical museology, museum presentation and communication, museum education, Technical Museum in Brno.

1. Introduction

The phenomenon of technical museology started to gain momentum in the world in the late 18th century and, in particular, in the second half of the 19th century, in relation to the industrial development, as well as in connection with the organisation of world exhibitions showcasing the achievements of science and technology, art and material culture of the individual countries. Thanks to their appealing nature, technical exhibits and collections became extremely popular with visitors to world exhibitions, and later also to museum exhibitions of a technical character. It is not

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difficult to explain what fuelled this popularity and interest. It was the character of the technological and scientific exhibits which, in the form of attractive presentation, visualization, demonstration, quality and accessible commentary, have a potential to captivate most visitors. Needless to say, answers to questions such as How did it originate? How was it made? How does it work? What is behind it? How was it used? etc. interest the larger part of the population.

Technical museology has undergone a complex development in the last 200 years, in the course of which it evolved into its current form. The changes did not only concern the character of acquisitions and collecting activities; the forms of presentation and direction of the institutions changed as well, in line with the general focusing of museums chiefly on visitors and the social importance of the preserved artefacts. What manner of presentation and communication is typical of museums of science and technology? What are the current possibilities of approaching the general public in the field of technical museology? What is the role of technical exhibits in the educational process? These are some of the questions this article seeks to answer.

2. Materials and methods

The sources and literature on the subject are rich, and concern the area of general museology (Waidacher, 1993; Stránská, Stránský, 2000; Maroević, 1993; Beneš, 1997; selected issues of the current practice in Marstine, 2006) and the history of museology (Špét, 1979; Bazin, 1967; Alexander, 1979 et al.), as well as the concept of technical museology (e.g. Majer, 1982; Neustupný, 1968; Pubal, 1965) the foundations of which were only laid in the 20th century (Kirsch, 2017a; Kirsch, 2017b). These also include the modern discipline of museum pedagogy centred on work with visitors (e.g. Hein, 2002; Jagošová et al., 2010; Brabcová, 2003 et al.), and museum presentation as one of the basic forms of the mediation of the content of museum collections (e.g. Beneš, 1981; Dolák, 2015; Šobáňová, 2014a; Šobáňová, 2014b; Dean, 1996; Lord, Lord, 2002; Bukačová et al., 2014 et al.).

The methods and methodological procedures in this article thus predominantly focus on the analysis and synthesis of information from general and technical museology, and on the mentioned museum activities in the area of presentation and museum-pedagogical activities of technical museology.

As the contribution does not only examine the theoretical level but also concrete examples derived from practice, namely the example of the Technical Museum in Brno and its visualization and presentation of science and technology, we will also focus on the analysis and description of the activities of this institution. The article outlines the forms of the mediation and communication of the content of the museum's collections; special attention will be also paid to informal education and to the visualization of science in informal education organised in the Technical Museum in Brno. Among methodological procedures ,the data was acquired, in particular, by the content analysis of the museum's documents and examples of its activities. In the examination of the presentation and educational activities of the museum, information from interviews with some of its workers was employed, as well as from their specialist contributions at conferences and observations made during excursions with museology students taking place in the main building of the museum.

2.1. Communication and presentation in the museum

Exhibition activities of museums in general belong with the basic activities of these institutions. Without the mediation of the preserved relics of society (material and immaterial artefacts) and nature (naturfacts) these institutions would lose their primary purpose and would only serve as storage spaces for collections. By extension, their use would be considerably limited, and although they could serve as sources of scientific research (Kačírek et al., 2013: 43), their general potential would remain untapped. The public character of museums, their ostensive approach in presentation activities (ostension – showing or exhibiting of originals) the objective of which is, among other things, to inform, to explain particular phenomena and events, to mediate experiences (Desvallées, Mairesse, 2011: 40-41), thus particularly accentuates the educational function of museums (Etické kodexy, 2014: 27; Dean, 1996: 5-6; Beneš, 1981a; Vakhromeeva, 2018).

The study approaches the exhibition activities from the perspective (theory) of museum communication and (the theory of) museum presentation, and this also holds true specifically in the case of exhibition activities of museums of technical nature. Specialist literature often treats the terms "museum communication" and "museum presentation" as synonyms, yet this is not always the case in museum practice. Museum communication is a broader term which also involves s museum presentation (Dolák, 2015: 9-10). Museum communication is any manner in which a museum communicates with the public, whereas museum presentation is a particular outcome of an exhibition programme (Beneš, 1997: 87) the main purpose of which is to mediate the content of collections or their part in different forms. To achieve this, museums use original, authentic items (presented as exhibits) as the bearers of museality (Stránský, 2000: 34), i.e. with a documentation and heritage value. These are supplemented with various models, dummies, plans, maps, photographs, audio-visual technology, modern IT technology, etc. Museums thus communicate with the public chiefly through the display of the authentic original items listed above, exhibits (ostension), and through signs, symbols and representations substituting originals (Dolák, 2015: 13). As a result, an exhibition is a combination of several means of expression accompanied by descriptive and explanatory texts and graphic elements with different functions, as well as exhibition elements (furniture), illumination, sound, etc. helping to create the desired ambience.

The Czech museologist Josef Beneš distinguished between the use of museum collections for specialist (scientific) purposes and educational ones (Beneš, 1997: 87). In museums of technology, both types are employed. One of them is prioritized, depending on the character of activities in a particular museum. Exhibition presentations are more of an educational character, or educational-didactic character, focused on usage, function, production process, and in terms of subjects on scientific, technical and technological aspects of the evolution and progress of society.

Museum communication has many functions. In museums of technology, the informative, instructive (explanatory) and educational functions come o the fore, followed by the cognitive function, which, however, does not mean that the content of exhibitions is not adjusted to suit a broad spectrum of visitors. While in the past museum workers laid emphasis on the scientific approach and scientific systematization targeting the needs of researchers (Beneš, 1997: 89), current presentation activities seek to find a balance between the scientific approach and the aesthetic, didactic and dramatic approaches with an effort to accentuate the emotional effect as well as the functional one stressing effective communication of information.

The purpose of museum presentations is to access certain aspects of visitors' interest, attitudes and values so that they would realise and understand the meaning of the displayed objects. The selected form of communication thus has to lead to the understanding of the content, relations and contexts existing between collection items and other means of expression, making up a compact and synthetic whole. Presentation forms in museums differ, not only according to the theme of exhibitions but also through manners in which they express their content. Nowadays, the content has most often the character of authentic and documented presentation in which a key part is played by original exhibits in a particular context, in relation to other means of expression, with efforts to respect their role and meaning in the original environment.

In terms of exhibition activities, the following goals have been defined (Lord, Lord, 2002: 18-22):
- contemplation, with emphasis on the aesthetic aspect;
- comprehension, with emphasis on context and theme;
- discovery, with emphasis on visitors' own findings;
- interaction, with emphasis on live demonstration and multimedia.

The concepts of presentation activities of museums blend all these aims. Emphasis is placed on what most corresponds to the character and theme of an exhibition. Naturally, it also depends on a pre-designed concept in regard to visitors.

The authors understand the term visualization in the title as a transfer of abstract notions (mentefacts) into exhibitions, i.e. as a visual form within a particular subject (Beneš, 1981: 15). In their presentations museums employ a special exhibition language (Kačírek et al., 2013: 43) based on the context, especially on the mentioned authentic objects and other means of expression. The exhibition language combines different accents of approaching visitors (Dolák, 2015: 30-33).

The visual aspect of exhibition activities ranks them, due to their character, with design. In fact, exhibition design is an art, artistic rendering of a particular subject. David Dean uses the phrase "science of arranging the visual" (Dean, 1996: 32). The main objective is to mediate the content of an exhibition, aptly, clearly, comprehensively, truly and in an attractive fashion.

2.2. Museum pedagogy

Museum pedagogy is a social science focused on museum education. It is rooted in museology and pedagogy, and is closely linked with a large number of cultural disciplines, the humanities and social studies, as well as with natural and technical sciences. In the centre of its attention are specific educational processes taking place in the museum or associated with it. Museum pedagogy has seen a global rise in interest in the last decades, and is also thriving in the Czech Republic. In the last twenty-five years of social development when the country's museums resumed the free interpretation of their collections, the society's interest in museums has gone up, as has the interest of museums in visitors.

The fulfilment of the educational potential in museum work is in the Czech context connected with the establishment of the first museums in the late 18th century and early 19th century, and has been present in their development ever since. In the mid-19th century there also emerged the idea that museum workers should be experts in some of the disciplines represented in museums. A concept of the education of the current and future museum workers started to take shape; apart from their disciplines, they were also expected to master specific museum activities of the selection, hoarding and presentation character, with ambitions to create university forms of education (Comp. e.g. Tišliar, 2017: 586-592). The term "museum pedagogy" (or museo-pedagogy) first appeared in the Czech specialist literature between the 1980s and 1990s. However, as a scientific discipline it fought for recognition throughout the 1990s fraught with discussions regarding its justification, status within museology and incorporation in the system of pedagogical sciences (Jagošová, Mrázová, 2015: 56-64; Jagošová, Jůva, Mrázová, 2010). Nonetheless, this period was marked by several highly important stimuli for the dynamic development of museum pedagogy as an autonomous scientific discipline and its application in museum practice (Jagošová, 2016: 3-5). Museum workers in particular sought paths towards approaching visitors and targeting their interest in museums, often outside their main focus in the museum. The position of museum pedagogue was viewed as necessary in this context, although it was not yet anchored in legislation. The development of museum pedagogy and the profession of museum pedagogue is supported, apart from individualized practice of the institutions, by the possibility of joining professional associations and a selection of various forms of specialist education, as well as by the study of foreign literature (e.g. Falk, Dierking, 2000; Hooper-Greenhill, 1996; Sandell, 2002) and study trips.

Efforts at further professionalization of museums logically tend towards the deepening of competencies of the branch, as well as to a closer and better collaboration between the individual museum professions, the individual museums and related institutions at different levels of museum work. In communication with visitors emphasis is placed on expertise and skills rooted in the approach of the disciplines in a museum and pedagogy which significantly contribute to the overall effect of individual museum projects for the public (Jagošová et al., 2016). International professional standards for educational work of museum pedagogues with the public (Excellence in Practice, 2005) are rooted in the principles of accessibility, reliability and development aimed at the support of education as a key to fulfil the purpose and goals of the museum institution. They are based on the prerequisites of professionalism:

1. targeting the museum public and community;
2. respect and understanding in regard to the diversity of the museum public;
3. expertise in the content of education and methods of museum education;
4. development of visitors' interest and support of the principle of collaboration;
5. development of education as a key to fulfil the purpose and goals of the museum institution;
6. positive attitude towards the learning process, and obligation to promote the knowledgeability and culture-awareness of citizens (Excellence in Practice, 2005: 10).

An inseparable part in the support of visitors' interest and the principle of collaboration is to involve the wide museum public and the individual communities with respect and understanding in regard to their diversity. In connection with visitors, museums are often discussed as educational institutions, places where people go to learn and expand their intellectual horizons; in addition, some museums promote themselves as destinations attractive for tourists. Yet museums can offer much more: they can be genuine recreational environments where people come to relax, recharge their batteries and improve their mental and physical conditions (Wasmer Andrews, 2010).

3. Discussion and results

3.1. Technical museology and museums of technology

The modern origins of technical museology go back to the year 1794 when the Conservatoire des Arts et Métiers (Academy of Arts and Crafts) was established in Paris (Waidacher, 1993: 96).

This area of museology centres on the documentation of the achievements of science and technology in the history of society. Museums of technology collect, preserve and present machines, instruments, models, means of production of all kinds, as well as anything manufactured by people (Lalkovič, 2005: 26-27). They document the progress in technology, and they also indicate prospective future visions for science and technology. The first important museums of technology were founded in the 1870s in Moscow (Polytechnické múzeum, 1872); Paris (Abbaye Saint-Martin-des-Champs Museum, 1879) and Vienna (Technologisches Gewerbemuseum, 1879) (Lalkovič, 2005: 26-27). Significant progress in technical museology came in the first half of the 20th century. Its prime movers were museums in Munich (Deutsches Museum, 1906) and Chicago (Museum of Science and Industry, 1933) (Alexander, 1979: 67-68, 70-72; Hartung, 2010: 87-92).

These institutions were preceded by museums of applied arts in the mid-19th century, developing in connection with the expansion of cities, industrialization and the development of arts and crafts. Presentation activities of these museums included, in particular, representations of the complete manufacturing process of the production of artefacts, from the processing of material, through the individual phases (stages) of the production process to the finished product, by means of period technological procedures (Waidacher, 1993: 94-95). The objective of such elaborate presentations was to educate visitors. The first museums of applied arts mentioned in specialist literature were the South Kensington Museum in London (1851; since 1899 the Victoria and Albert Museum) followed in 1864 by the Österreichisches Museum für Kunst und Industrie, Vienna (Lalkovič, 2005: 24). The earlier historical periods were marked by the collecting of artefacts of technical nature, from the Middle Ages onwards, gathered in various cabinets of curiosity which later gave rise to art collections (Nekuža, 2016: 70). The cabinets, however, mostly functioned as random collections, often with bizarre selection criteria. Items collected included, for example, historical crafts and renaissance artworks that were to serve as models, for inspiration and education (Nekuža, 2016: 71). The mediation of technological procedures and approaches to the technical and artistic processing of products was important, in the industrialization period and especially in the second half of the 19th century, for the developing secondary schools and universities of technical character, the curricula of which involved more and more often examples of technological procedures. Museums thus became places where it was possible to experience, visually or through other senses, science and progress in technology.

This long-term development resulted in the constitution of several types of museums of technology. The first group aims at the general documentation of science and technology from the perspective of development, at the international, national and regional level. The second one specialises in a particular area (e.g. mining, astronautics, transport; it also includes company museums). In addition, there are in situ monuments of technical interest that function as museums (e.g. mines, mills), and some rare material is held by geographical museums. Recent years have seen a boom of science centres which, unlike museums of technology, have a purely educational function, ignoring preservation and involvement in science and research (Vieregg, 2007: 114-119; Geschichte des Museums, 2008: 235-261). The musealization process in this type of museums, i.e. dissemination of facts (Stránský, 2000: 31-32, 57), concerns not only the collecting and preservation of technical artefacts as autonomous items selected from the real world; museums of technology in the area of musealization and documentation also seek to cover broad context relations, the natural environment of artefacts, their connections with society, their meaning and use, etc. For these reasons, in museums of technology the collection, science and research activities involve the study of the technological processes of production of objects, the principles of their functioning, and information about their original use. This information is subsequently employed by museum workers in the cataloguing and processing of the collections of technical character, but it is also equally useful in museum presentations and communication with visitors, as well as in various accompanying museum-pedagogical activities. This manifests that in museums of technology natural and technical sciences are mainly employed as applied disciplines, the information from which is used, in popular form, in communication with visitors.

The specific position of museums of technology inspired efforts to address this phenomenon at the theoretical and general level. One of the pioneers of this approach as early as the beginning of the 20th century was Oskar von Miller (1855–1934), director of the museum in Munich (Deutsches Museum) who pursued the theory and methodology of exhibition activities at the educational level, and in collecting activities prioritized acquisitions connected with teaching (Jůva, 1994: 24). Efforts to address the issues of technical museology only got their institutionalized form gradually. Apart from national professional organisations (active, for example, in France, Italy, India, Russian Federation and the Netherlands) (Sister organisations, 2018), an institution particularly active in technical museology was CIMUSET (International Committee for Museums and Collections of Science and Technology), one of the international committees of the ICOM international museum organisation (International Council of Museums) established in 1948 which brings together traditional museums documenting the development of science and technology as well as institutions focused primarily on education (science centres) and other specialised institutions (planetariums, health museums, etc.) (Baghli et al., 1998: 95). The European network of science centres and museums uniting over 350 organisations has operated since 1989 (The European network, 2018).

3.2. Technical Museum in Brno

Brno has a long tradition as a centre of industrial production and technical education, and from the 18th century onwards objects of this kind were collected by local learned societies. In the 19th century, these exhibits also emerged in the collections of some local museum institutions (Moravian Museum, Museum of Applied Arts). However, attempts at the establishment of the first museum of technology in Moravia were long without success. The conditions were most favourable in 1924 when the Preparatory Committee for the Establishment of the Technical Museum was set up within the Association of Czechoslovak Engineers. The museum did not come into existence until 1951, through the transformation of the Archive for the History of Industry, Commerce and Technical Work. However, the museum was established as a subsidiary of the Technical Museum in Prague. The Technical Museum in Brno only started to function as an independent institution in 1961. In the following years, its activities covered over thirty disciplines, as well as displays devoted to some leading scientists (e.g. Viktor Kaplan), and the museum developed a number of additional activities. Apart from creating permanent exhibitions (e.g. water and steam power, computer technology) and temporary shows including travelling ones, the museum prioritized work with visitors which was of high standards, based on extensive quantitative and qualitative research. The museum also took part in research activities and was among the applicants of state research projects. The collections were housed in the historical building of the former Convent of St. Ursula in Brno, and the museum gradually came to administer several sites of special technical interest**:** Old Ironworks**,** near Adamov (metallurgy exhibition), a baroque smithy in Těšany (exhibition of smithery and wheel-making), a windmill in Kuželov (exhibition devoted to the history of windmills), a watermill in Slup (exhibition of mill technology), Šlakhamr in Hamry nad Sázavou (exhibition of iron-milling). A turning point in the development of the institution came after the Velvet Revolution in 1989. Due to restitutions, the museum lost its original exhibition premises and moved to a reconstructed building in Brno-Královo Pole. It was opened to the public in 2003.

The Technical Museum in Brno is administered by the Ministry of Culture of the Czech Republic, and its main objective is "…to acquire, collect and preserve, catalogue, process and present to the public collections of museum nature" (Zřizovací listina Technického muzea, 2012).

In accordance with these goals, the museum chiefly gathers material evidence of the development of technology, industry, transport, industrial production, architecture and science, both Czech and international, yet it naturally also focuses on the territory of Moravia and Silesia. In addition, the museum conducts science and research activities in the field of industrial archaeology, conservation and restoration, and in collaboration with universities and further specialist institutions teaches courses in museology, conservation and restoration (Střednědobá koncepce Technického muzea, 2013).

As a research organisation it prepares specialist assessments and recommendations, its workers carry out scientific research in archives and conduct analyses in the areas of the museum's specialist activities, which the museum then employs in its work and publishes. The museum works consistently with the public, especially children and young people, and organises activities of voluntary workers, especially through the Circle of the Friends of the Technical Museum (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 4). Its activities are not restricted to the CR, however, and the museum has launched close collaboration with a number of institutions of a similar kind abroad. The museums sees its future potential, among other things, in the creation of programmes for the specialist and general public, focus on new technological and industrial disciplines which would expand the documentation scope of the institution, and in the revitalization of its property, aimed at its better use (Střednědobá koncepce Technického muzea, 2013). Its organisational structure can be divided into three basic parts: economic and operational, technical and specialist. In view of the subject of this article, activities in the last two categories appear most relevant. In the technical category, emphasis is on the activities of the department of exhibition production and the run of technical monuments, and of the department of communication and marketing. The specialist group consists of workers in charge of the individual technical disciplines covered by the collections (i.e. aviation and astronautics, public transport, crafts, textile, history of the blind), activities of methodology centres, six technical monuments and a library. The administrators often include people formerly active in particular industrial branches, and many are educated in museology.

3.3. Presentation and communication activities of the TMB

To demonstrate the results of its presentation and communication with the lay and specialist public, the TMB has created "presentation systems", open and active systems responding to the problems and needs of the society (Střednědobá koncepce Technického muzea, 2013). They comprise permanent exhibitions, technical monuments in situ with functioning technologies and displays involving life in the region, in the form of organising joint programmes, open days, shows of historical vehicles, meetings and sales popular with visitors. There are also lectures, seminars, workshops; the museum collaborates with almost a thousand members of the Circle of the Friends of the Technical Museum in Brno, participates in teaching at schools, in the supervision of diploma theses, etc. The TMB has received numerous prizes in this respect awarded to its scientific and professional community, one example being the award for presentation activities in the Gloria musealis national competition.

3.3.1. Scientific and publishing activities of the TMB

The TMB as a research organisation conducts basic and applied research and experimental development, organised by the Department for the Documentation of Science and Technology (DDST). The DDST carries out specialist activities within the individual technological and scientific branches concerning the collections, as part of research tasks and grant projects. Their results are presented to the public through exhibitions and extensive publishing activities. Apart from exhibition catalogues and specialist literature devoted to leading figures in Moravian technology and museology subjects, there are book series (*Studies from the History of Technology and Industry*, *Acta Musei technici Brunensis*) and periodicals (*Archeologia technica*, *Historická fotografie*, *Textil v muzeu*). The published texts are often selected from contributions for international conferences organised by the museum. The TMB also holds regular lectures, seminars and workshops for the specialist and lay public.

Another organisational component of the TMB, the Conservation Methodology Centre (CMC), has both a specialist and methodological function. It is a national institution in the area of conservation and restoration of items from the collections of museums in the CR. It came into existence in 2003 and its main objective is "to increase the effectiveness of the protection of movable cultural heritage and quality care for collections at all levels." (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 7). It supports and develops protection of and care for the cultural heritage in the Czech Republic, provides methodology and consultancy assistance in the field, especially to the administrators of museum-type collections. Its workers also lead conservation and restoration courses at the Science Faculty and the Faculty of Arts of Masaryk University, Brno (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 7). The CMC publishes methodology manuals on the protection and processing of the materials of collection items, and issues the *Fórum pro konzervátory-restaurátory* journal. It played a major part in the publishing of the Professional Ethic Code for Conservators and Restorers of the Association of Museums and Galleries of the Czech Republic.

One of the specialised workplaces of the museum, somewhat unique among museum institutions in the Czech Republic, is the Department for the Documentation of the History of the Blind People (1 employee) (Maruščáková, 2005; Hluší, 2001: 2; Smýkal, 1996). The original Brno Museum of the Blind established in 1992 was incorporated into the structure of the TMB as one of its departments in 2000 (Smýkal, 1996). In accordance with the Establishment Charter of the TMB it documents, through collection-building activities, specific aids for the blind and visually impaired employed in the Czech Republic, and systematically processes the collections. The register of the Department of Typhlopedic Information documents the history, life, culture and education of the blind and visually impaired children and adults. The department also runs a library of books in Braille and different types of embossed Roman script, and historical audio recordings. In its specialist activities it collaborates with the United Organisation of the Blind and Visually Impaired. Beyond its scientific activities and collection activities in its field (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 7) it offers consultancy and practical assistance to other museums. This assistance concerns, in particular, presentations and education, for example, consultations involving a suitable exhibition approach to selected topics and the inclusion of adequate didactic elements (with regard to visitors with different types and intensity of impairment), in the selection of suitable exhibits for haptic and interactive study, preparation and printing of exhibition texts and captions, invitations and promotional materials in Braille made on the special Pichta typewriter. The department also works with primary and secondary school students and university students and associations for the blind and visually impaired (lectures, seminars, guided tours, excursions, etc.). The department runs its own research and publishing activities including study trips abroad and participation in international projects (Publications on the history and the present of museums of the blind – see e.g. Hluší, 2004; Hluší, 2014).

Important help in the documentation and specialist activities of the museum comes from volunteers, members of the Circle of the Friends of the TMB. In collaboration with experts they centre on research into and preservation of major technical sites and objects, organisation of lectures, field trips and other events. There currently exist several sections focusing on car models, historical vehicles, barrel organs and mechanical devices, photography, history of fire brigades, historical stereovision, history of aviation and model-making, optics and electron microscopy, space rocket model-making, renovation of historical aircraft, communication technology, antique clocks, textiles and windmills (Klub přátel TMB, 2018).

3.3.2. Exhibition activities of the TMB

The museum administers a central building housing permanent exhibitions and several sights of special technical interest in the South Moravia Region and the Vysočina Region (within 90 km of Brno). They include the following sites of technical interest: The Dutch type of a windmill from 1842 (national cultural monument, Kuželov); fortification complex on the southern border of Czechoslovakia created in 1935–1938; infantry block with original weaponry and equipment used by the army in 1960–1999 (Šatov),; baroque blacksmithery from 1700 with a blacksmith's workshop from the 19th century (cultural monument, Těšany); watermill with a display on the historical development of the miller's trade (national cultural monument, Slup); The Old Ironworks – a metallurgical complex with a blast furnace and an exhibition about metallurgy (national cultural monument, near Adamov); Šlakhamr – Iron-Milling, Lumbering and Housing of the Last Owners (cultural monument, Hamry nad Sázavou) (for more information see Sights, 2018). The TMB is not located in the city centre and the sights are in small towns or villages, or outside them. The museum focuses, in particular, on the presentation of permanent exhibitions; temporary shows are not among its main features (Machová, 2017: 23-25). This is why it is important to attract visitors with interesting innovations in permanent exhibitions, or special events (e.g. Museum Night Festival, Christmas workshops, programmes in the sights of special technical interest). The main building has a wheelchair access to all its sections, and the visitors' facilities include areas for parents (changing room for families with babies) (Services, 2018). The administrators of the individual collections/sights collaborate on the exhibitions with the Department of Exhibition Production and the Administration of Technical Monuments with the staff of 14 employees (Produkce výstav a provoz památek, 2018).

The main building of the TMB houses 16 exhibitions. Some of them are related to Moravia and Silesia (historical regions of today's Czech Republic) and introduce phenomena typical of this region (e.g. metallurgy, water-powered engines, cast iron, Brno on two wheels). Yet documentation also involves a number of more general subjects (computer technology, historical vehicles and aircraft engines). The core exhibits of some of the displays come from the earlier periods (e.g. stereovision) but are adjusted to suit modern conditions and needs. The items on show are chiefly of retrospective character, and at the educational level focus on visuality and visitors' active participation. The interactive element typical of museums of technology is most distinctly represented in the Technology Playroom, the main purpose of which is to introduce visitors, especially the younger generation, comprehensively and in entertaining form, to mechanics, optics, acoustics and electricity. The method for the study of these phenomena is experiment, when visitors can, with the use of provided instructions, freely handle experimental models and observe the results of their activities. The devices are regularly replaced and replenished. A specific feature is the Culture of the Visually Impaired section documenting the historical development of care for this group of disabled citizens including teaching aids, printing devices and examples of typical crafts and occupations (Permanent displays, 2018). The in situ sights located outside Brno function on a similar principle. In their work with visitors they employ the effect of the authentic environment (Sights, 2018). In contrast, the subjects of the exhibitions centre on some modern trends in the development of technology and present specific parts of the collections, yet they also often focus on the recent past with the aim to make visitors reminisce over their youth. (There is Never Enough Lego, The World of Model-making). Exhibitions in the TMB have a synthesizing character and are staged on the occasions of major anniversaries. One example is an event prepared in collaboration with further museums entitled Industry in Moravia, accentuating the most important and typical branches of industry in the region in 1908–1928 (Výstavy, 2018).

3.3.3. Educational activities of the TMB

In the organisation structure of the museum, the area of communication with the public and education is supervised by the Communication and Marketing Department (9 employees), consisting of the head of the department, a spokesperson and positions regarding the area of project and programme activities (including the coordination of activities with the Circle of the Friends of the TMB), communication with the public (including administration of the museum website and social networks) and museum pedagogy (guiding, lecturing and pedagogical activities).

The department mediates communication with the public and is in charge of the promotion and popularization of the museum. With the Department for the Documentation of Science and Technology it creates programmes for visitor groups and facilitates their implementation through guides and lecturers. It communicates with the media, administers the website, portals and social networks, records statistics, analyses and specialist activities, especially regarding museum presentations and the number of visitors (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 7).

Two museum pedagogues are responsible for the educational activities in the TMB. One of them is in charge of education at the exhibitions in the main building, the other in the technical sights. Another pedagogue working in the museum is a lecturer leading art and technology workshops for both primary schools and the public. Specialist museum workers and volunteers (for example, university students of museology) help with programmes taking place during special events.

As the TMB has not yet completed its educational strategy, visions in the area of education are only reflected in annual reports or follow from exhibition plans. The museum pedagogues are graduates of pedagogy and museology, with long practice in the museum environment (or with practice in education).

In 2017 the TMB buildings opened their gates to 155,752 visitors, which is a record number and 20 % increase in comparison with the previous year. 69 % of the people visited the main building in Brno. Programmes implemented within exhibitions in 2017 reached the total of 961 groups for 21,530 visitors (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 30-35). The museum pedagogues work directly with school groups (primary and secondary schools) and families with children. They also work with groups of senior citizens and visitors with special educational needs. Individual visitors are currently not in the centre of the museum's attention as regards controlled education.

The museum pedagogues also participate in the Museum Night, city camps for children, festivals of science and technology, etc (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 32). The types of programmes executed include guided tours, workshops and educational programmes with both educational and relaxation purposes. Programmes for school groups follow the state curricular documents for the individual stages of formal education (National Curricula, 2011–2018). The main building of the TMB currently offers, apart from programmes for current exhibitions, seven educational programmes for permanent exhibitions combined with five regular art and technology workshops where pupils can manufacture products connected with the subject (Pro školy, 2018).

The museum pedagogues share the descriptive and didactic analyses of the programmes at conferences or through publishing activities.

Fig. 1. School group with museum pedagogues in Technical museum in Brno

In the offer of educational programmes, the museum pedagogues specifically target school groups (chiefly primary and secondary school students, less often children from kindergartens), and focus on the organisation of regular art and technology workshops (for both schools and the general public). For families with children, the offer of special programmes in the main building is limited (Výroční zpráva Technického muzea v Brně za rok 2015, 2015: 19-21; Machová, 2017: 23-25).

Fig. 2. Technical monument in situ - Windmill in Kuželov - and family groups

The current form of inter-generation learning at the permanent displays in the main building of the TMB has not yet been systematically developed (Machová, 2017).

The museum does not provide any self-access materials for the displays (the museum pedagogues use worksheets almost exclusively in combined programmes) which would link inter-generation learning with the exhibits. The only exceptions in recent years have been worksheets for families with children, created on the basis of cooperation with the museum pedagogues as outcomes of diploma theses (e.g. Dalecká, 2012; Golianová, 2014; Machová, 2017).

Although these materials are not available for families with children during their visit to the museum, the individual displays involve interactive elements, didactic elements or play activities for children. The busiest sections across the whole spectrum of visitors include The Crafts Lane and the Technology Playroom (Výroční zpráva Technického muzea v Brně za rok 2017, 2017: 36), which is, due to the demanding maintenance of the interactive exhibits, constantly expanded and outdated exhibits are regularly replaced. In terms of education, pedagogical work is more intense in the sights of technical interest, the popularization of which has been one of the museum's priorities in recent years through their reconstruction, promotion and a selection of programmes. All-day programmes take place, owing to their character and locations outside Brno, at weekends and during the summer season, and primarily target families with children.

4. Conclusion

Museums are institutions with a significant potential for the presentation and popularization of science and technology. They visualize information and present it to the wide public, mainly through exhibition and educational activities, and they also collaborate with the specialist public (meetings, publishing activities). The case study regarding the Technical Museum in Brno (Czech Republic) describes the broad spectrum of its activities, from scientific work and care for collections to communication and presentation activities. The museum involves permanent displays and temporary exhibitions, technical monuments in situ with functioning technologies and exhibitions that are part of life in the region, taking the form of joint cultural events and educational programmes, open days, shows of historical vehicles, festivals of museum nights and other projects attracting a wide audience. The Technical Museum organises lectures, seminars, workshops, and collaborates with almost a thousand members of the Circle of the Friends of the TMB in Brno. In addition, its workers are engaged in pedagogical activities in schools (including universities), lead diploma theses, etc. The future specialist development of this institution will involve a conceptual and well-prepared approach to its educational plans in the form of an educational strategy for the museum including further educational goals such as the promotion of inter-generation learning in the main building of the museum, search for new ways of the popularization of its scientific activities and the support of the general public's interest in the country's cultural and technical heritage.

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