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COMPARATIVE ANALYSIS OF THE COMPETENCES OF GYMNASIUM STUDENTS IN LOWER SILESIA DISTRICTS¹

Abstract: The paper presents the analysis of students' scores in compulsory examination administered in the last grade of the gymnasium. The conducted multivariate analyses allowed to determine spatial diversity and dynamics of the competences of students in the lower secondary level of education in Lower Silesia districts between 2002 and 2010. The following alarming conclusions are the result of this research: in most districts the gymnasium students are prepared for further stages of education and for applying the knowledge and skills in life only to a medium or weak degree; the number of districts in which the gymnasium students obtained good and very good results decreased in 2010; number of points scored in the competence areas where creativity and constructive thinking was significantly decreased.

Key words: evaluation of learning results, cluster analysis, agglomerative hierarchical clustering procedures.

1. Introduction

The goal of the long-term and complex reform of educational programmes, teaching methods and structure of educational system introduced in Poland in 1999 was “the improvement of quality in formal educational system and its adjustment to requirement of the knowledge-based economy, ensuring access to lifelong learning system for the entire society and facilitating closer connections between students, academic society and business, whose presence in other countries favours the process of technology transfer” [*Perspektywy gospodarki...* 2004].

The reform was based on six main principles, namely: new educational system, external examination system, separated management and supervision, new professional status of the teaching staff, new system of financing and curriculum reform.

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One of the key elements of the reform was the introduction of new types of schools, and the elimination of some existing school types. Among other changes, the reform of the educational system from 1999 introduced gymnasiums. The education at gymnasium level is general, and the students are from 13 till 16 years old. The learning process is concluded with a gymnasium examination, taken by students of the third grade in April. The examination consists of two written parts: humanities and sciences. The results of the examination do not influence graduation but they are taken into account in the recruitment process for secondary level – by secondary, vocational or technical schools.

The goal of this research is to compare the results of the gymnasium examination between 2002 and 2010, and to evaluate the changes in gymnasium students' competences in this period.

2. The data and methods

The research was based on the results of the gymnasium examination obtained by students from Lower Silesia between 2002 and 2010. The individual results of each student were the basis for calculating the mean results for each district. The obtained numbers were then used to evaluate the degree of similarities of the districts in respect to the examination results in six areas of competences.

In the humanities part of the gymnasium examination, the results describe two levels of students' competences:

- reading and the interpretation of texts;
- creation of own text.

In the sciences part, the results regarded four competence areas:

- application of terms and procedures in the area of exact and natural sciences, essential in life and further education;
- finding and using information;
- identifying and describing facts, relationships and dependencies in particular cause-effect, functional, spatial and temporal;
- application of integrated knowledge and skills to solve problems.

To evaluate the degree of similarities of the examination results in Lower Silesia districts, the agglomerative hierarchical clustering algorithm was used, allowing to distinguish the clusters with similar objects (see e.g. [Haerdle, Simar 2007]). The agglomerative hierarchical procedures start with each object as a separate cluster, and in consecutive stages of agglomeration merge the objects which are close to each other, using the appointed distance matrix. The procedure ends when a cluster containing all the objects is created. The respective variants of the procedure differ by the way the distance between the objects is defined. In this research, the Ward method was applied, in which the distances are calculated using the following formula:

$$d_{ri} = \frac{n_i + n_s}{n_i + n_s + n_t} d_{si} + \frac{n_i + n_t}{n_i + n_s + n_t} d_{ti} - \frac{n_i}{n_i + n_s + n_t} d_{st},$$

where: d_{ri} – the distance between new r cluster and i cluster,
 d_{st} – the distance, at which on a given stage of agglomeration the merging of clusters s and t occurs,
 n_i, n_s, n_t – the number of objects in clusters i, s, t .

The splitting of the dendrogram is executed by “cutting-off” the tree diagram at the point where the most appropriate number of clusters is created. This point can be determined by the dendrogram analysis, the analysis of the process of agglomeration plot, or by calculation of Grabiński measure, based on the maximum of the quotient of subsequent distances for which the merging occurs (see [Grabiński 1992]).

3. Classification of the districts between 2002 and 2010

Figure 1 presents the dendrogram which is the outcome of the application of Ward’s method and Grabiński measure for the dataset from 2002.

Both the process of agglomeration plot and the Grabiński measure indicated an identical point of “cut-off”, formed after 28 steps, one cluster containing all the districts.

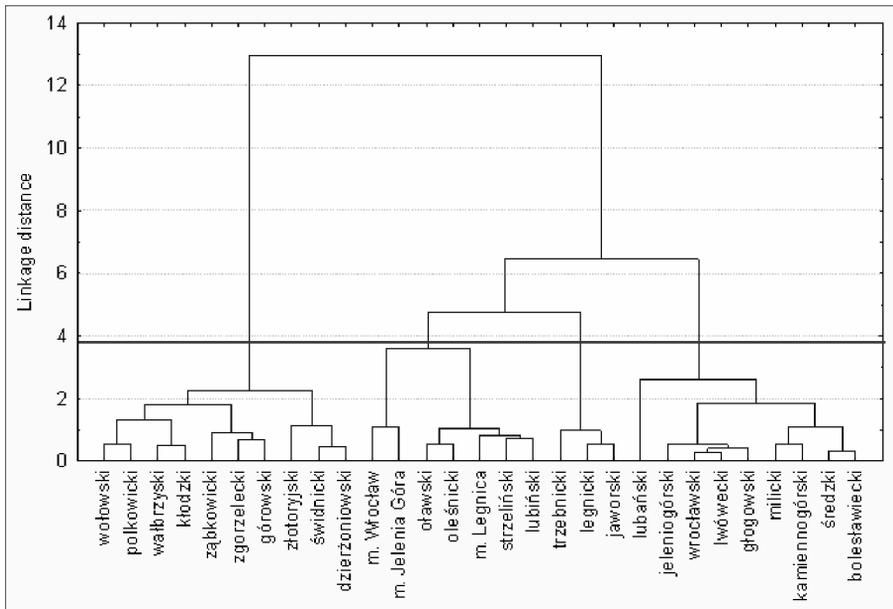


Figure 1. The process of agglomeration of Lower Silesia districts in respect to the gymnasium students’ results in the year 2002

Source: own elaboration.

The local maximum was then chosen and the dendrogram was divided into four clusters:

- cluster I represented by three big cities: Wrocław, Jelenia Góra and Legnica, and districts: oławski, oleśnicki, lubiński and strzeliński;
- cluster II containing districts: trzebnicki, legnicki and jaworski;
- cluster III which grouped the districts: lubański, jeleniogórski, wrocławski, lwówecki, głogowski, milicki, kamiennogórski, średzki and bolesławiecki;
- cluster IV which contained the districts: górowski, kłodzki, dzierzoniowski, polkowicki, złotoryjski, wałbrzyski, świdnicki, zgorzelecki, ząbkowicki and wołowski.

The level of knowledge and competences in the distinguished clusters is different; the differences may be evaluated by comparing values of centroids for all clusters (see Figures 2 and 3). Territorial regions from cluster I are characterized by the highest average scores. Cluster II contains the districts where the gymnasium students obtained good results in the gymnasium examination in almost all competence areas, except for the competence *creation of own text*, where the scores were on average worse than in cluster III. Cluster III groups the districts where knowledge and competences of gymnasium students were at medium level, with the exception of competence *creation of own text*, where the average result was good. The lowest scores were obtained by the students attending gymnasiums in districts classified as cluster IV.

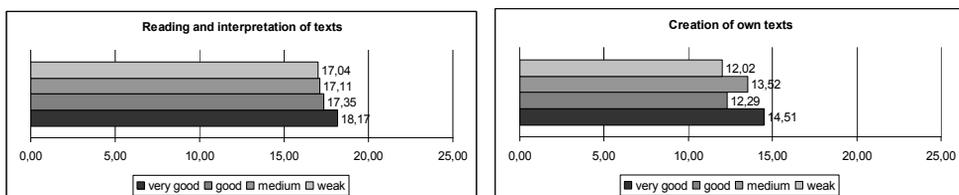


Figure 2. Values of centroids for the humanities examination in 2002

Source: own elaboration.

In both areas of the humanities examination the students could score a maximum of 25 points. In the area *reading and the interpretation of texts* the students' scores were substantially higher than in the area *creation of own text*. In cluster I, containing the districts with higher scores, the competence of reading and interpretation is just below 72% of the maximum number of points, whereas in the area *creation of own text* the students from the best districts obtained on average about 58% of the maximum number of points. In medium and weak clusters only slight differences in average results in the area *reading and the interpretation of texts* are noticeable (the students scored respectively 68.4 and 68.2% of the maximum number of points). However substantial differences occur in the area *creation of own text* – the average scores are 54.1 and 48.1% of the maximum number of points.

In the science examination the students were evaluated in four competence areas:

- application of terms and procedures in the area of exact and natural sciences, essential in life and further education;
- finding and using information;
- identifying and describing facts, relationships and dependences in particular cause-effect, functional, spatial and temporal;
- application of integrated knowledge and skills to solve problems.

In the two first areas the maximum number of points was 15, in the last two 10 points.

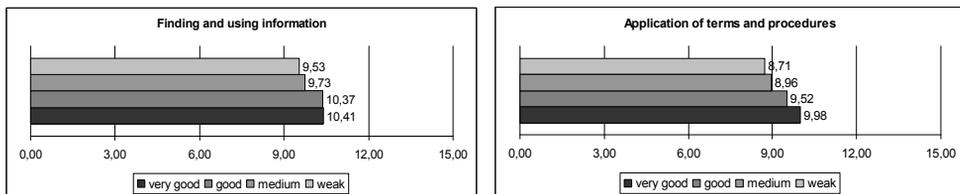


Figure 3. Values of centroids for the sciences examination in 2002

Source: own elaboration.

The analysis of the results of the gymnasium science examination in 2002 prove that the students are most skilled in the area *finding and using information* (area II), where in all clusters students scored 2/3 of the maximum number of points, or very close to 2/3 (respectively: the very good cluster – 69.4%, the good cluster – 69.1%, the medium cluster – 64.9% and the weak cluster – 63.5% of the maximum number of points).

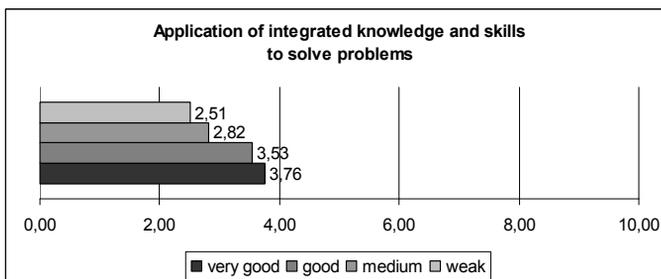


Figure 4. Values of centroids for the competence area *application of integrated knowledge and skills to solve problems* in 2002

Source: own elaboration.

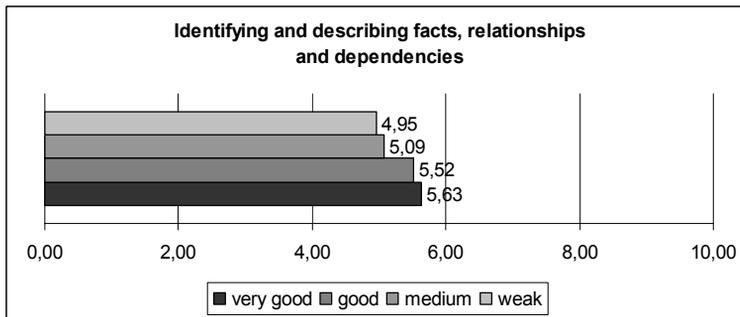


Figure 5. Values of centroids for the competence area *identifying and describing facts, relationships and dependencies in particular cause-effect, functional, spatial and temporal* in 2002

Source: own elaboration.

The competence area *application of integrated knowledge and skills to solve problems* was the most difficult for gymnasium students from all districts in Lower Silesia. The students from the districts in the best cluster were able to score only slightly more than 1/3 of the maximum number of points (37.6%). The students from the weakest districts scored only 25.1% of the maximum number of points.

Only somewhat better results were obtained by the students in the competence area *identifying and describing facts, relationships and dependencies in particular cause-effect, functional, spatial and temporal*. The students from clusters I and II obtained just above half of the maximum number of points (56.3 and 55.2% accordingly). The average score of the students from the weakest cluster did not exceed 50% (the exact figure was 49.5%).

The spatial distribution of the districts classified to certain clusters is presented in Figure 6.

The spatial distribution indicates substantially strong district diversification in respect to the scores in the gymnasium examination – it is difficult to point out distinct conglomerations of districts with similar average scores. However, two specific neighbouring groups of districts with extreme average examination scores can be distinguished. Four districts from the cluster with very good results (oleśnicki, oławski and strzeliński, as well as the city of Wrocław) border five districts from the weakest cluster IV (ząbkowicki, dzierzoniowski, świdnicki, kłodzki and wałbrzyski). The second apparent pattern in the spatial distribution of the examination results is the concentration of the districts with higher scores in central and eastern parts of Lower Silesia.

Considerable changes in the level of gymnasium students' competences, both in the humanities and the sciences examination, took place in 2010. The dendrogram for 2010 is presented in the Figure 7.

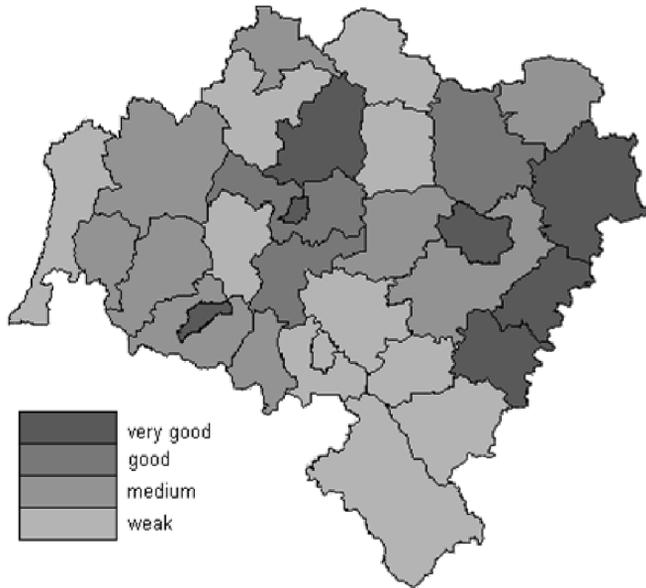


Figure 6. Classification of the Lower Silesia districts in respect to the scores in Gymnasium Examination in 2002

Source: own elaboration.

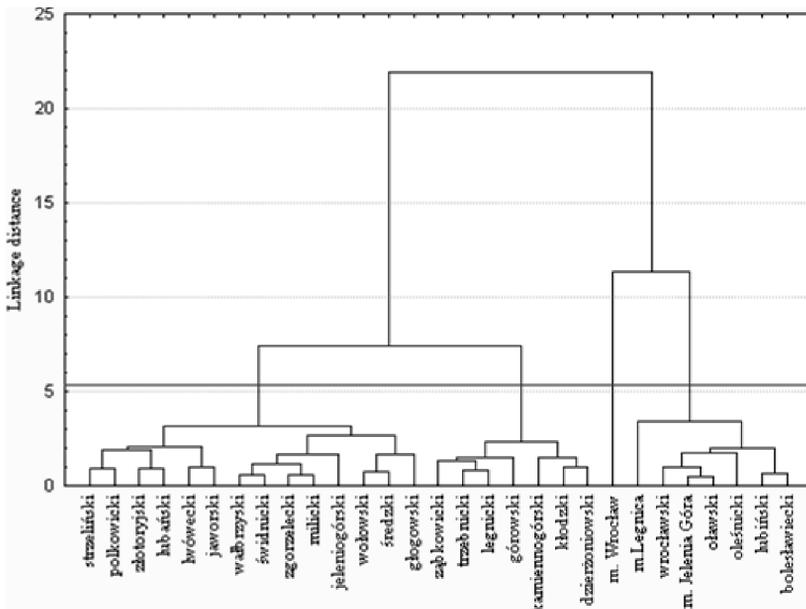


Figure 7. The process of agglomeration of Lower Silesia districts in respect to the gymnasium students' results in 2010

Source: own elaboration.

The Grabiński measure indicated the division of the dendrogram, which leads to four clusters:

- cluster I represented by the city of Wrocław;
- cluster II which contained the districts: legnicki-grodzki, jeleniogórski-grodzki, wrocławski-ziemski, oławski, oleśnicki, lubiński and bolesławiecki;
- cluster III containing districts: ząbkowicki, trzebnicki, legnicki-ziemski, górowski, kamiennogórski, kłodzki and dzierzoniowski;
- cluster IV which grouped the districts: strzeliński, polkowicki, złotoryjski, lubański, lwówecki, jaworski, wałbrzyski, świdnicki, zgorzelecki, milicki, jeleniogórski-ziemski, wołowski, średzki, głogowski.

The differences in the level of knowledge and competences in the distinguished clusters may be evaluated by comparing the values of the centroids in respective groups (see Figures 8 and 9). The Wrocław district forms a separate cluster with the highest average results. Cluster II may be characterized as the aggregate of territorial regions with good average scores obtained by students in the gymnasium examination. Cluster III encompasses the districts in which the knowledge and competences were at medium level. The weakest results were obtained by students attending gymnasiums in the districts classified to the cluster IV.

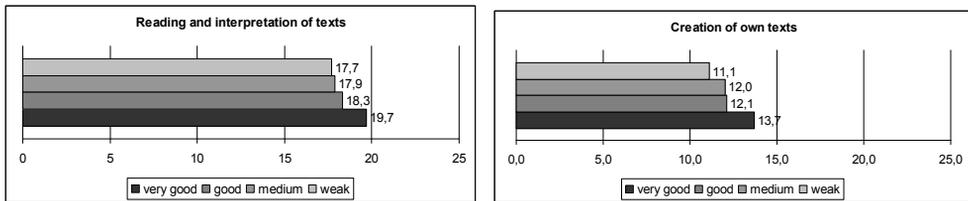


Figure 8. Values of centroids for the respective competence areas in the humanities examination in 2010

Source: own elaboration.

In 2010 in both areas of the humanities examination the maximum number of points that could be obtained was 25. The results draw attention to the fact that the students did better in the reading and texts interpretation part than in the exercises designed for evaluation of the ability to create own texts.

Moreover, a higher differentiation was reported in the competence area *creation of own text* (maximum difference 2.6 points) than in the area *reading and the interpretation of texts*. The parts of the examination, where active and creative approach, including analysing, ordering, synthesizing, arguing and editing own expressions were marked, were particularly highly evaluated for the students from Wrocław in comparison to other students. It is worth noticing that those kinds of competences were manifested at a similar level by the students in clusters II and III.

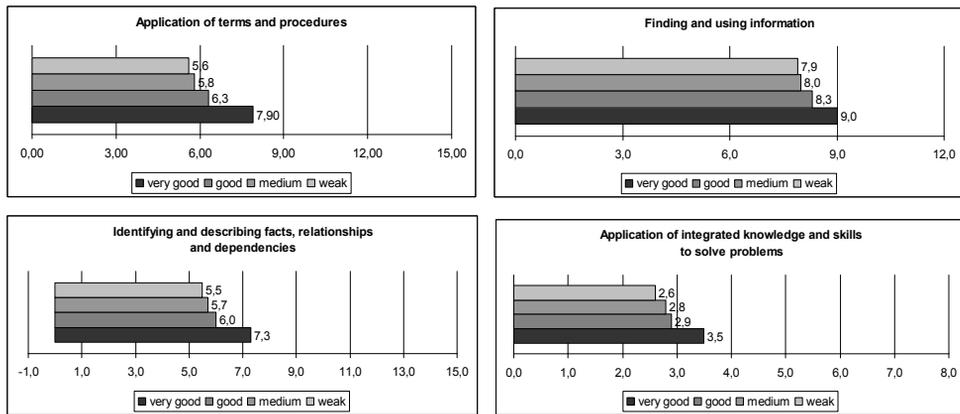


Figure 9. Values of centroids for the respective competence areas in the sciences examination in 2010

Source: own elaboration.

In 2010 in the sciences examination, the students could obtain 15 points in the area of application of terms and procedures, 12 points in the area of finding and using information, 15 points in the area of identifying and describing facts, relationships and dependences, and 8 points in the area of application of integrated knowledge and skills to solve problems. The least problematic for gymnasium students were the exercises involving finding and using information – students from Wrocław obtained in this area on average 75% of the maximum number of points, whereas in the districts from cluster IV 65.8%. The lowest scores were reported in case of the exercises testing application of integrated knowledge and skills to solve problems – the Wrocław students on average obtained less than half of the maximum number of points (43.8%), and the students from districts in cluster IV only 32.5%. The biggest differences between the respective clusters occurred in the area *application of terms and procedures*, up to 2.3 points between Wrocław and the districts from cluster IV. Spatial distribution of the districts classified to certain clusters is presented in Figure 10.

The fact that the gymnasium students from big cities with district rights (Wrocław, Jelenia Góra, Legnica) obtained distinctly higher results in comparison to the surrounding districts, is especially worthy of attention. The scores in gymnasium examination showed substantial territorial diversification. The groups created by the agglomerative hierarchical clustering algorithm do not provide the basis to differentiate regions, which are spatially compact and homogeneous in respect to obtained results. A very general conclusion is that the districts located in the northern and eastern parts of Lower Silesia better results were more frequent, whereas in southern and western parts weaker results were reported.

Table 1 presents the comparison of the classifications between 2002 and 2010.

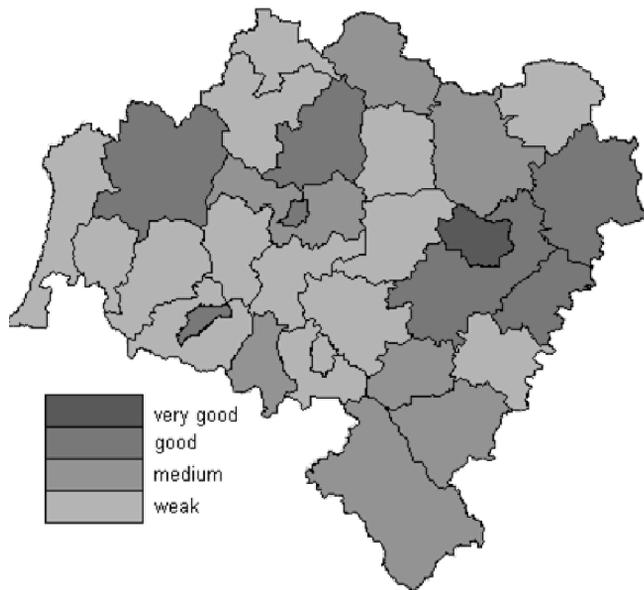


Figure 10. Classification of the Lower Silesia districts in respect to the scores in Gymnasium Examination in 2010

Source: own elaboration.

Table 1. The clusters for Lower Silesia districts in respect to the scores in gymnasium examination between 2002 and 2010

| Cluster | 2002 | 2010 |
|-----------------------|--|---|
| I – very good results | cities: Wrocław, Jelenia Góra, Legnica, districts: oławski, oleśnicki, strzeliński, lubiński | city: Wrocław |
| II – good results | districts: trzebnicki, jaworski, legnicki-ziemski | districts: Legnica, Jelenia Góra, wrocławski-ziemski, oławski, oleśnicki, lubiński, bolesławiecki |
| III – medium results | districts: lubański, jeleniogórski-ziemski, wrocławski-ziemski, lwówecki, głogowski, milicki, kamiennogórski, średzki, bolesławiecki | districts: ząbkowicki, trzebnicki, legnicki-ziemski, górowski, kamiennogórski, kłodzki, dzierzoniowski |
| IV – weak results | districts: wołowski, polkowicki, wałbrzyski, kłodzki, ząbkowicki, zgorzelecki, górowski, złotoryjski, świdnicki, dzierzoniowski | districts: strzeliński, polkowicki, złotoryjski, lubański, lwówecki, jaworski, wałbrzyski, świdnicki, zgorzelecki, milicki, jeleniogórski-ziemski, wołowski, średzki, głogowski |

Source: own elaboration.

The disproportions in the number of districts in each cluster, especially in those which group the best and the worst results, are apparent. In 2010 the district city of Wrocław formed a separate cluster with the best results, which noticeably deviated from other regions. In 2002 other cities with district rights, namely Jelenia Góra and Legnica, as well as districts oławski, oleśnicki, strzeliński and lubiński were classified to the cluster with best results alongside Wrocław. According to the latest research, the students attending the gymnasiums in the capital of Lower Silesia outdistance other gymnasium students in the region. It seems that the level of education is highly polarized – the very high level in Wrocław is accompanied by a substantially lower level in other districts. Another alarming fact is that in both considered periods the cluster which grouped the districts with the worst results was the most numerous. Moreover the number of districts classified to the worst cluster increased – in 2010 it contained fifteen districts, whereas in 2002 ten districts. There were differences in classifications between 2002 and 2010, however, only in two cases did extreme changes in the assignments to clusters occur – in 2002 the students from strzeliński district were classified as one of the best, eight years later they were assigned to the worst cluster. Similarly the lower position was occupied by the students from jaworski district – in 2002 they belonged to the group with good results, whereas in 2010 to the cluster with the worst results. All other changes in the classification were within the limit of just one level.

The changes which occurred in the percentages of the points scored by the students in separate areas of competence are also worth mentioning. In 2010 in all clusters the gymnasium students obtained on average results better by 3.9% in the area *reading and the interpretation of texts* in comparison to 2002. In the sciences examination the improvement in the results was present in two areas:

- in the area *finding and using information* the students obtained on average almost 2.5% more of the maximum number of points;
- in the area of *application of integrated knowledge and skills to solve problems* a little over 5% more.

Unfortunately in three competence areas the students obtained fewer points in 2010 in comparison to 2002:

- the decrease in the area *creation of own text* was 3.4%;
- even higher decline was reported in the area *identifying and describing facts, relationships and dependences* – 12.1%;
- the highest decrease was in area I – *application of terms and procedures in the area of exact and natural sciences, essential in life and further education* – more than 19%.

The fact of such an extreme decline in the level of accomplishment of the exercises from area I of the science examination is very disturbing. The low level of competences in the area of using knowledge to solve problems should be the reason for profound analyses aimed at investigating the causes of such a situation, as well as formulating findings and conclusions which could assist the teachers work with students.

4. Conclusions

The knowledge and competences which the students gain during the education process in gymnasiums should assist them at the beginning of their adult life, help them in solving difficult life problems, and provide guidelines in making serious decisions, for example the decisions of their further educational path. Unfortunately the conducted analysis provides alarming conclusions.

Less than half of the 29 Lower Silesia districts can be described as good and very good in terms of gymnasium students results – in 2002 38% of all districts belonged to this group, while in 2010 the number dropped to 27.6%. Therefore in most districts the gymnasium students are only fairly or even poorly prepared for the next stages of education and to applying the knowledge and skills in real-life problems.

This conclusion is supported by a decrease in the number of points scored in the three competence areas involving creativity and constructive thinking. The students' abilities to illustrate and analyse problems, to identify regularities, to create the scenarios of the possible solutions, to synthesise the available information, to build argumentations and to edit own texts, are limited. In those areas the gymnasium students' results are much lower than in the case of imitative tasks, which do not involve conceptual and creative approach.

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ANALIZA PORÓWNAWCZA UMIEJĘTNOŚCI GIMNAZJALISTÓW W POWIATACH DOLNOŚLĄSKICH

Streszczenie: W artykule poddano analizie wyniki obowiązkowego egzaminu przeprowadzanego na zakończenie nauki w gimnazjum. Przeprowadzona wielowymiarowa analiza porównawcza dla lat 2002 oraz 2010 pozwoliła określić przestrzenne zróżnicowanie i dynamikę umiejętności uczniów kończących drugi szczebel nauczania w województwie dolnośląskim. Z analizy danych wynikają niepokojące wnioski: w większej części powiatów gimnazjaliści są tylko średnio i słabo przygotowani do dalszych etapów edukacji oraz stosowania wiedzy i umiejętności w praktyce życiowej; w 2010 r. zmniejszyła się liczba powiatów, w których gimnazjaliści uzyskali dobre i bardzo dobre wyniki z egzaminu; nastąpiło zmniejszenie liczby punktów dla umiejętności sprawdzających kreatywność i twórcze myślenie egzaminowanych.

Słowa kluczowe: ewaluacja wyników nauczania, analiza skupień, hierarchiczne procedury aglomeracyjne.