

## **CHEMOMETRIC ANALYSIS OF SCHOOL LIFE IN VARNA**

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**Abstract.** In this paper, the authors' collective is presenting a questionnaire, designed and tested by them for the regular evaluation of the educational environment in high schools. It consists of 50 multiple choice questions about quality of learning and relations between school children and teachers. The questionnaire was tested on the students of three high schools in Varna. It was distributed to male and female students of the 9<sup>th</sup>, 10<sup>th</sup> and 11<sup>th</sup> grades. The data set consists of 693 respondents – schoolboys and girls characterized by their answers to 50 questions each one ranked by values from 1 to 5. Non-hierarchical cluster analysis was applied to find patterns of similarity between the questions or between the pupils. The results verified the constructive value of the questionnaire as a method of evaluation of the educational environment in high schools.

**Keywords:** questionnaire; Educational environment; high school; cluster analysis.

### **Introduction**

A school's good atmosphere is a basis for increasing the educational quality, as it is a premise for the students' positive attitude towards their school (Tomova et al., 2014; Boyd et al., 2009). The relationships between students, as well as these with their teachers, are an important characteristic of the life within a school (Görsev, 2010; Telli et al., 2010; Vahedi, 2010). The evaluation of the learning environment is a significant factor in the evaluation of curriculums (Genn, 2001). Organising group assignments in class contribute to the formation of friendships between students and turn school life into an enjoyable experience. The belief that students are in a team with their teacher strongly motivates them to attend class (Akinoğlu & Tandoğan, 2007). The feedback

from students is undoubtedly important in order to monitor their opinions about the curriculums and the educational methods, the pedagogical approaches of instilling a spirit of cooperation, the relationships between students and their teachers. The systematic use of questionnaires would help indicate the problematic areas in the learning environment, in order for steps to be taken for their correction (Hoad-Reddick & Theaker, 2003; Aldridge et al., 2012). One aspect of the questionnaire would be monitoring whether current teaching practices are used, which can serve as an evaluation of the teachers' activities. For instance, although a big portion of Bulgarian teachers know and praise the opportunities created by problem-based learning, few of them apply it, due to the high amount of preparation it requires, and due to the need of significant changes in the perception of a class in order for it to be applied (Tafrova-Grigorova, 2010). This constructivist approach for active learning is undoubtedly effective, as it encourages the acquisition of new knowledge based on knowledge acquired in previous classes. It requires from students to be involved in activities that stimulate them to ask questions, to research, and to solve problems; which eventually leads them to the answers of real life problems (Overton, 2007; Hmelo-Silver, 2004). However, the testing of this learning approach requires feedback, in order for it to be appropriate to students' age and study level. The social differences between students are a stress factor which has serious implications on a school's educational environment. Under stress, students are more prone to perceiving the environment as negative, which decreases their motivation for attending classes (Maul, 1980).

The use of a specific questionnaire is especially important for teachers and high schools' administration, in order for them to receive quality feedback from their students. Effective management of the learning process requires the introduction to appropriate changes aimed at improving the educational environment; and this can only be done after the results from its evaluation have been analysed. A link between the environment in which students learn, and the quality of their work has been identified and documented (Boyd et al., 2009; Jawaid, 2013). The positive environment gives students self-confidence and it motivates them to achieve better results. The way students perceive their educational environment is highly influenced by the available learning facilities, by their expectations, by their cultural background and upbringing and by their past education (Genn, 2001; Jawaid et al., 2013). This illustrates the importance of students' opinions on the educational environment.

In this paper, the authors' collective is presenting a questionnaire, designed and tested by them for the regular evaluation of the educational environment in high schools. The questionnaire was tested on the students of three high schools in Varna: High School of Mathematics "Doctor Peter Beron"; High School of Commerce "Georgi S. Rakovski"; Fifth Language School "Joan Exarch".

## **Materials and methods**

### *Questionnaire*

Questions
1. I am fully aware of the educational aims of the high school curriculum.
2. Teachers encourage me to participate in class.
3. The learning strategy that I am using is suitable for me.
The study subjects are too many for me to spend more time studying the ones that I like.
5. Education is focused on the students' future needs.
6. Education is done in a way that increases my competence.
7. I rarely feel bored during class.
8. The enjoyment from studying for certain subjects is greater than the stress involved.
9. Teachers distribute teaching time adequately for covering the learning content.
10. Education is too focused on learning facts by heart.
11. I don't think that my current education is preparing me for university.
12. I am able to concentrate in class easily.
13. Non-traditional educational methods (role-playing, solving problems, discussions, etc.) help me understand the educational content better.
14. Aggression is a daily occurrence within this school.
15. My problem-solving skills evolved during my education.
16. During group problem-solving, answers come up more easily.
17. I can discuss my interests with my teacher.
18. I am responsible for my education. Teachers are only guiding me.
19. Education increases my belief in my knowledge and skills.
20. In education, it is important to achieve results, regardless of the way they are achieved.
21. I would put more effort into a subject which is interesting for me.
22. I am able to achieve my personal educational interests during classes.
23. The learning load is optimal and equally distributed throughout the week.
24. The order of the teaching subjects in a day is not rational and well thought of.
25. The school is equipped with opportunities for engaging use of free time.
26. Teachers often give us group projects, presentations, assignments, which help me get close to my peers and to take in the learning content more easily
27. We are always ready to help peers in need.
28. I am satisfied by my choice of school.
29. Teachers treat students with respect.
30. There is good communication between parents and students.
31. Teachers always come well prepared for class.
32. Teachers communicate well with students.
33. Teachers use plenty of real life examples during class.
34. Most teachers are authoritative.

35. Students provoke annoyance in teachers.
36. Teachers' criticising helps us rethink our behaviour.
37. Teachers' exam marking is done on a favouritism basis rather than students' knowledge.
38. Teachers often conduct the classes in non-traditional forms (game, discussion, debate, press conference).
39. I have good friends at school.
40. I rarely feel lonely.
41. I have the opportunity to establish good interpersonal relationships.
42. I do not feel different than my peers in a social aspect.
43. The environment in class seriously affects my mood.
44. The school needs well-equipped classrooms, in order for teaching to run smoothly.
45. Group work helps establish friendships.
46. We prefer exams to be run as tests.
47. I share my problems with my head teacher and I rely on them for advice.
48. We would like to be able to suggest additional topics, according to our own interests.
49. If we know how to solve a problem, we share the solution with our peers.
50. We discuss between us how to solve problems given by the teacher.

Questionnaire consists of 50 questions, corresponding to the 5-point Likert psychometric scale for measuring social aptitudes. There are: questions related to the educational process (1, 7, 10, 11, 19, 23, 24, 50); questions related to the role of the teacher in the educational process (2, 9, 21, 28, 29, 31, 32); questions related to the relationship between teacher and pupils (14, 16, 17, 30, 33, 34, 35, 37, 38, 45, 47, 48); questions related to the personal attitude of the pupils to the educational process (8, 12, 15, 18, 20, 22, 25, 39, 40, 41, 42, 49); questions related to optimization of the educational process (3, 4, 5, 6, 13, 26, 27, 36, 43, 44, 46). Answers were thus given in points; the highest number of total points corresponding to a maximal positive view of school life.

The possible answers are: I strongly disagree.; I somewhat disagree.; I am not sure.; I somewhat agree.; I strongly agree.

#### *Statistical approach*

In this study non-hierarchical clustering of the input data was used. The advantage of this method is that one could preliminary select the number of clusters into which the input data should be classified. Therefore, in order to cluster the 50 questions from the questionnaire 5 clusters were chosen, which corresponds to the number of categories into which the questionnaire could be subdivided from theoretical point of view. For the clustering of the pupils, participating in the study the number of clusters chosen was three since the participants are from grades 9, 10,

and 11. It is difficult to expect that the supervised clustering will result in exactly the same preliminary categories but, at least, it give a starting point for proper data interpretation. This type of cluster analysis allows the identification of smaller groups of specific questions (outliers), to which participants in the questionnaire have a specific attitude. All calculations were performed with software package STATISTICA 8.0

The data set consists of 693 objects – schoolboys and girls of three high schools in Varna, grades 9, 10, and 11, characterized by their answers to 50 questions each one ranked by values from 1 to 5 of a questionnaire about quality of learning and relations between schoolchildren and teachers. The male to female ratio of students is approximately

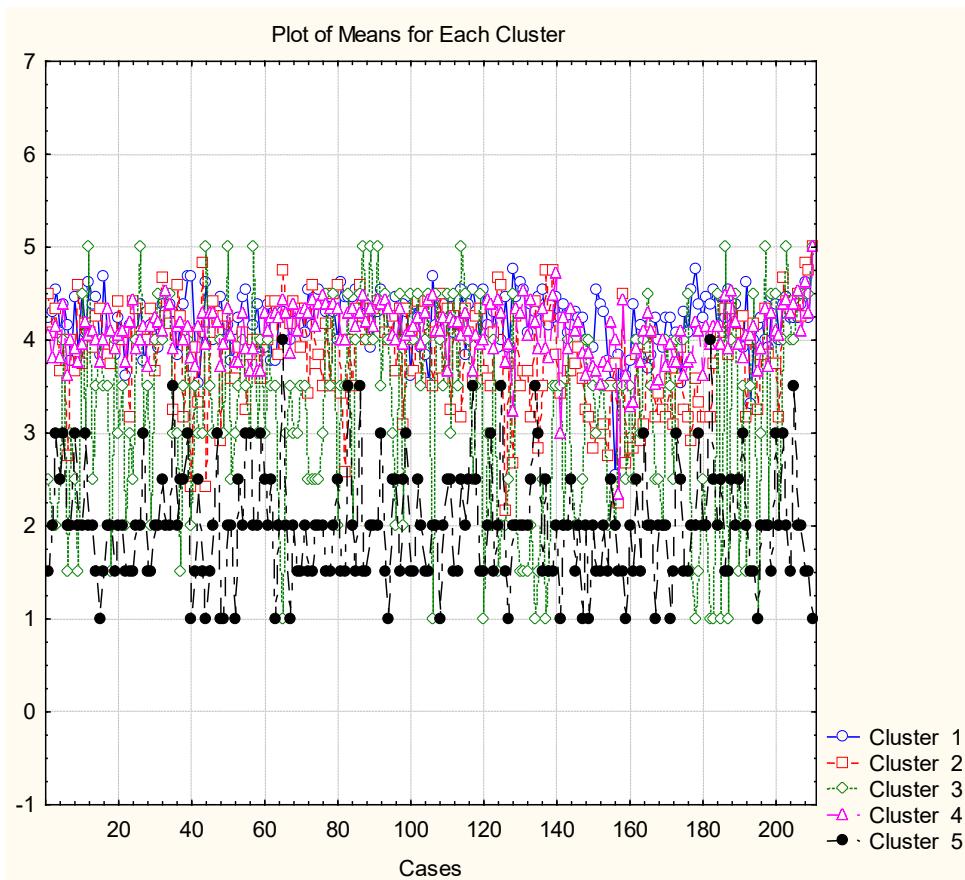
## Results and discussion

*Non-hierarchical cluster analysis of the 50 questions - assessment of the learning process*

After the non-hierarchical cluster analysis the questions were grouped into five categories. The questions from the questionnaire are clustered differently for the three different schools (Table 1, Figs. 1 - 3), although in all of them five clusters are formed by non-hierarchical clustering of the variables (questions 1-50).

**Table 1.** Non-hierarchical cluster analysis of the questions

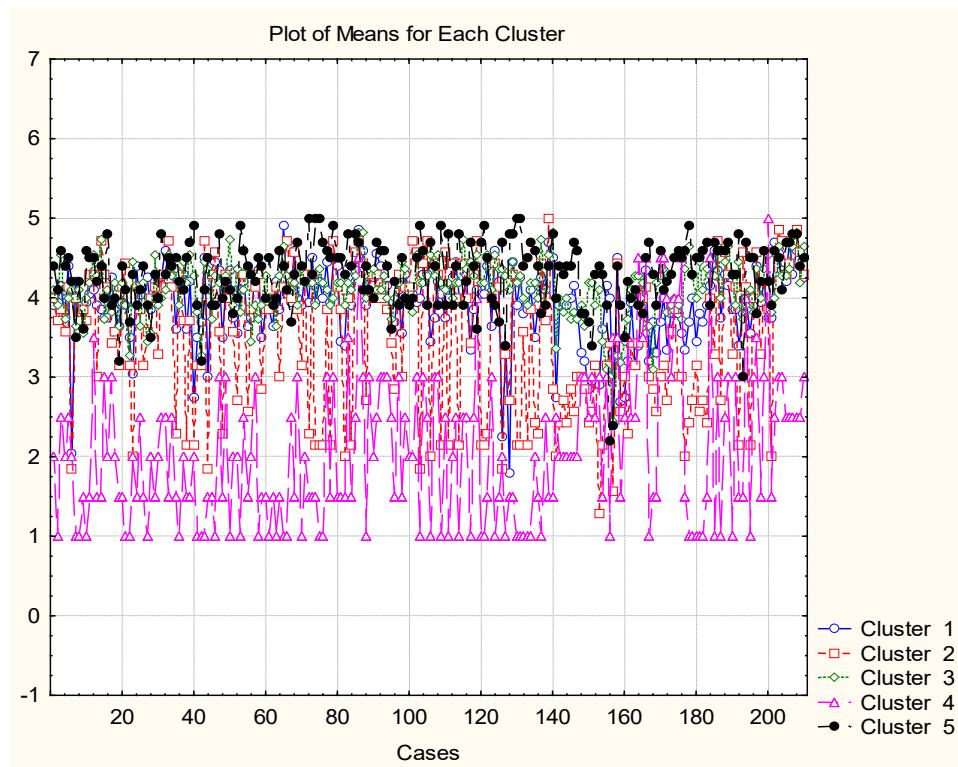
School	C1	C2	C3	C4	C5
Fifth Language School "Joan Exarch"	1, 2, 3, 7, 8, 9, 11, 12, 15, 17, 19, 22, 25, 29, 30, 31, 32, 33, 34, 36	5, 6, 20, 23, 35, 37, 38	16, 18, 21, 24, 28, 39, 40, 41, 42, 43, 44	<b>14, 26</b>	4, 10, 13, 27, 45, 46, 47, 48, 49, 50
High School of Commerce "Georgi S. Rakovski"	4, 10, 13, 16, 18, 27, 28, 40, 42, 44, 46, 48, 49	5, 6, 7, 15, 19, 20, 22, 23, 25, 33, 36, 37	<b>26, 38</b>	1, 2, 3, 8, 9, 11, 12, 17, 21, 24, 29, 30, 31, 32, 34, 39, 41, 43, 45, 47, 50	<b>14, 35</b>
High School of Mathematics	5, 7, 14, 24, 25, 38, 43	2, 6, 8, 9, 11, 12, 15, 17, 19, 22, 29, 30, 31, 32, 33, 36	10, 20, 34, 35, 37	1, 3, 4, 13, 16, 18, 21, 26, 27, 28, 39, 40, 41, 42, 44, 45, 46, 48, 49, 50	<b>23, 47</b>



**Figure 1.** Plot of means for each cluster (High School of Commerce “Georgi S. Rakovski”)

#### Attitude towards the questionnaire in different schools

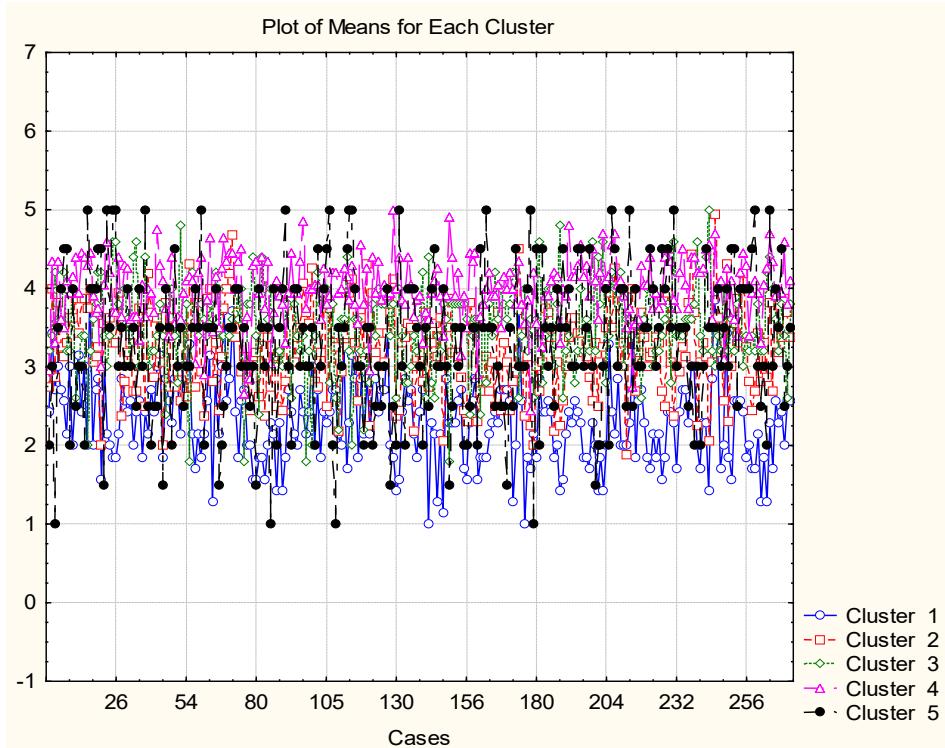
*High School of Commerce “Georgi S. Rakovski”, Varna:* Four questions indicate a specific attitude – 14, 26, 35 and 38. They are from different categories (questions related to the relationship between teacher and students – 14, 35 and 38 and questions related to optimization of the educational process – 26). It seems that the students are seriously engaged with the problems of aggression at school (14), introduction of common projects (26), teachers are annoyed by the students (35) and introduction of non-traditional lessons (38). All of these questions are characterized by very low scores meaning that the participants do not accept and approve aggression, feel the lack of common and non-traditional educational instruments and are not teased by their teachers.



**Figure 2.** Plot of means for each cluster (Fifth Language School “Joan Exarch”)

All other questions are grouped into three other big clusters. Cluster 1 includes dominantly questions related to the optimization of the teaching process and the personal attitude of the students to the educational process (group of educational and personal issues). Cluster 2 is also principally dedicated to the general educational strategy assessment and personal attitude questions (group of educational strategy issues). Cluster 4 is the biggest one and is dominantly linked to all categories of questions (group of general assessment).

As seen in Fig. 1 the participants give lowest marks for questions in clusters 5 and 3 which is already discussed above. For all other clusters the marks are relatively high (between 4 and 5), which is an indication that the students accept the general educational strategy, support the efforts for its optimization and are satisfied with the relationship with the teachers trying to have a personal attitude towards the educational process.



**Figure 3.** Plot of means for each cluster (High School of Mathematics)

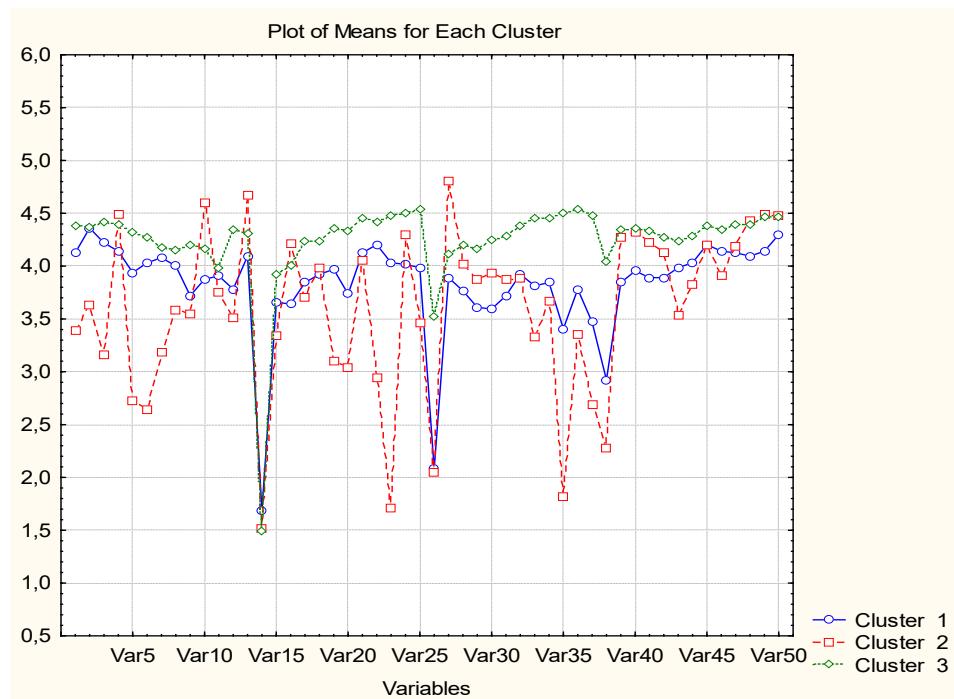
*High School of mathematics, Varna:* Cluster 5 contains two outlying object having low marks. It indicates that the pupils from this particular school have specific requirements for some elements of the general educational strategy and the relationship to their teachers. As seen in Fig. 3 the spread between the marks for almost all clusters is quite high. It may mean that the pupil responses to the questions are bidirectional and indicate quite individual opinions on all kind of question categories. That is why the content of each of the four larger clusters (1, 2, 3, 4) is of mixed non-specific character meaning that each clusters consists of questions from all categories. This particular school indicates very versatile individual responses.

*Fifth Language School “Joan Exarch”, Varna:* For the last school tested one outlying cluster is found (cluster 4), which contains lowest marks for questions 14 and 26 dealing with aggression and introduction of original educational projects. The students deny aggression decisively and suffer the lack of originality in the educational procedures. This situation is well illustrated in Fig. 2 (lowest marks

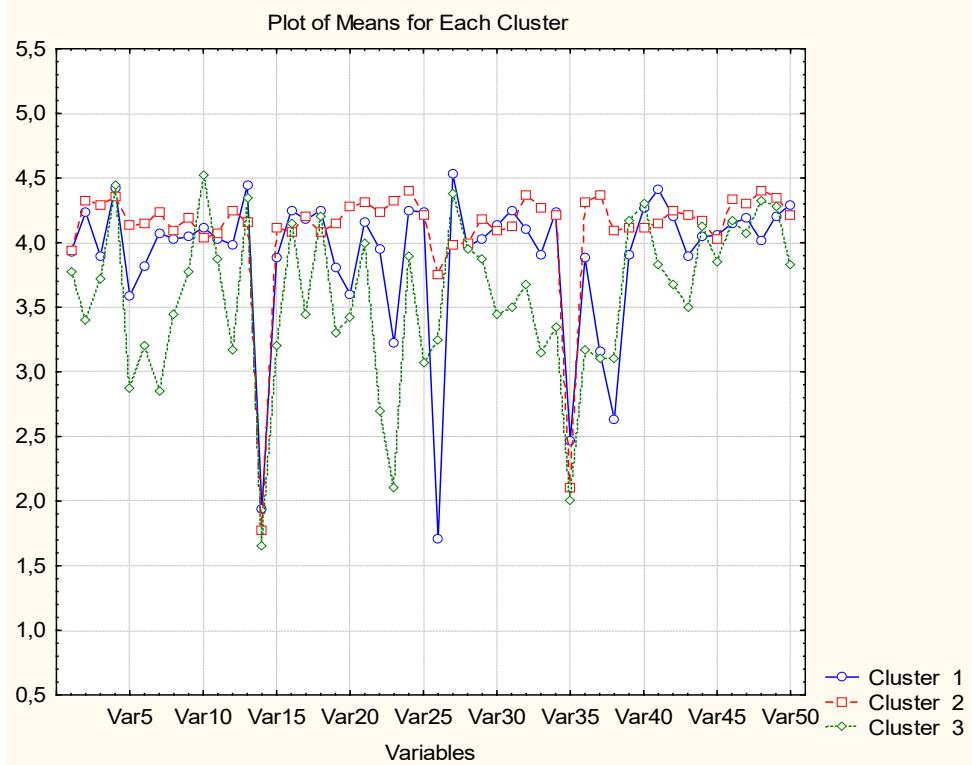
for cluster 4 from all participants. Clusters 1, 2 and 3 (as in the previous case of the mathematical gymnasium) are of complex mixed content comprising questions from all categories. The marks are highest and evenly distributed between 4 and 5. Cluster 5, however, is specific by its relatively low marks and includes dominantly questions from categories related to the pupil personal attitude to education and optimization of the educational process. The pupils are obviously critical to the present state and require improvement.

*Non-hierarchical clustering of the students from the different schools*

The supervised data treatment requires formation of 3 clusters as the preliminary condition was related to the three classes of students participating in the questionnaire (Table 2). It was interesting to find out if the response to the different categories of questions is linked to some extent with the student's age. Cases numbers 1 - 70 are from 9<sup>th</sup> grade, 71-140 – 10<sup>th</sup> grade and 141 – 210 – 11<sup>th</sup> grade students from the Fifth Language School (Fig. 4) and from the High School of Commerce (Fig. 5). For the School of Mathematics, the respective numbers are 1 – 91, 92 – 182 and 183 – 273.



**Figure 4.** Fifth Language School “Joan Exarch” (cases)



**Figure 5.** High School of Commerce “Georgi S. Rakovski”

*Fifth Language School “Joan Exarch”:* The separation with respect to the grouping of the students from the different grades (9, 10, 11) is not very specific. The 9<sup>th</sup> class students are dominantly in C1, the 10<sup>th</sup> graders – in C3 and 11<sup>th</sup> class students – in C2. But the separation with respect to age is not very distinctive or absolute. It might mean that the separation into clusters for this school (based on the questionnaire results) does not depend entirely on age variable.

If one considers the plot of means for each cluster of students, one can conclude that the grouping is due to the various attitudes of the members towards the various questions. Cluster 2 (C2) is characterized by the lowest marks given as response to the questions. Since C2 is dominated by 11<sup>th</sup> class pupils, a possible conclusion could be that the elder students are more critical and unsatisfied by the educational process. Surprisingly, highest marks are characteristic for C3 where dominantly 10<sup>th</sup> graders are included. The characteristics of C1 are very close to those of C2. Probably, the younger and eldest students are much

more critical that those who are in the middle of the period of education in this gymnasium.

*High School of Commerce “Georgi S. Rakovski”, Varna:* In this school there is even less specificity with respect to age. The pupils are distributed almost evenly in two big and one small cluster, so no specific dominance of age variable (9<sup>th</sup>, 10<sup>th</sup>, 11<sup>th</sup> grade) could be found.

The discrimination between the three clusters formed for this school is similar to that established for Fifth Language School “Joan Exarch”: for members in cluster 3 the lowest marks are given, for those in cluster 2 – the highest. Cluster 1 takes intermediate position resembling to high extent the average responses of cluster 3. No specific comment for the pupil’s attitude towards the educational process and the relations to teachers in the different age groups could be done.

*High School of Mathematics, Varna:* In this particular school the separation of the clusters with respect to the student’s age is unsatisfactory. The situation resembles that of High School of Commerce. The difference is that at the High School of mathematics the three clusters are almost equal in size (number of participants from all three categories). The discriminators for the clusters are, again, the average values for the marks to each question from the questionnaire. The averages for the three clusters are quite similar and homogeneous (this is a sign that in this school the attitude towards educational issues is much leveled without age variations): lowest marks for Cluster 1 and highest – for Cluster 3.

**Table 2.** Non-hierarchical clustering of the students from the different schools

School	C1	C2	C3
Fifth Language School “Joan Exarch”	<p><b>9<sup>th</sup> grade:</b> 1-4, 7-11, 13, 15-22, 24-28, 30, 36, 37, 41, 42, 45, 51, 53, 56, 60-64, 67, 69, 70</p> <p><b>10<sup>th</sup> grade:</b> 81, 95, 123, 125, 132, 134, 138</p> <p><b>11<sup>th</sup> grade:</b> 145-147, 155, 156, 162, 164, 168, 171, 173, 174, 185, 190, 193, 186, 198, 200</p>	<p><b>9<sup>th</sup> grade:</b> 6, 23, 35, 38, 40, 44, 48, 52, 55, 59, 72, 74,</p> <p><b>10<sup>th</sup> grade:</b> 75, 76, 78, 82, 84, 88, 96, 98, 103, 109, 111, 114, 117, 120, 121, 122, 126, 128, 130, 131, 133, 135, 136, 140-144,</p> <p><b>11<sup>th</sup> grade:</b> 148-154, 157, 159-161, 63, 167, 169, 170, 172, 175-183, 187, 192, 195, 201</p>	<p><b>9<sup>th</sup> grade:</b> 6, 12, 14, 29, 31-34, 39, 43, 46, 47, 49, 50, 54, 57, 58, 65, 66, 68</p> <p><b>10<sup>th</sup> grade:</b> 71, 73, 77, 79, 80, 83, 85-87, 89-94, 97, 99-102, 104, 105, 107, 108, 110, 112, 113, 115, 116, 118, 119, 124, 125, 129, 137, 139,</p> <p><b>11<sup>th</sup> grade:</b> 158, 65, 166, 184, 186, 188, 189, 191, 194, 197, 199, 202-210</p>

High School of Commerce "Georgi S. Rakovski"	<b>9<sup>th</sup> grade:</b> 2, 3, 7-9, 11, 13, 18, 22, 27, 37, 38, 42, 51, 56, 58, 60, 64, 65  <b>10<sup>th</sup> grade:</b> 72, 74-76, 78, 84, 96, 103, 106, 109, 111, 117, 120-122, 124, 125, 127, 130-134, 136-138, 140  <b>11<sup>th</sup> grade:</b> 142-147, 155, 156, 171, 178, 179, 181-183, 185, 187, 190, 192, 195, 196, 198, 201	<b>9<sup>th</sup> grade:</b> 1, 4, 5, 10, 12, 14-17, 20, 21, 24-26, 28-34, 36, 39, 41, 43, 45-47, 49, 50, 53, 54, 57, 61-63, 66-71, <b>10<sup>th</sup> grade:</b> 73, 77, 79, 80, 83, 85-95, 97, 99-102, 104, 105, 107, 108, 110, 112, 113, 115, 116, 118, 119, 123, 129, 139 <b>11<sup>th</sup> grade:</b> 158, 162, 165, 166, 175, 184, 186, 188, 189, 191, 193, 194, 197, 199, 200 202-210	<b>9<sup>th</sup> grade:</b> 6, 23, 35, 40, 44, 48, 52, 55, 59  <b>10<sup>th</sup> grade:</b> 81, 82, 98, 114, 126, 128, 135  <b>11<sup>th</sup> grade:</b> 141, 148-154, 157, 159-161, 163, 164, 167-170, 171, 173, 175-177, 180
High School of Mathematics	<b>9<sup>th</sup> grade:</b> 4, 21, 28, 34, 35, 38, 46, 48, 50, 52, 54, 56, 57, 60, 67, 76-78, 83, 85, 88, 90  <b>10<sup>th</sup> grade:</b> 101-103, 105, 109, 116, 120, 130, 137, 140, 142, 148, 154-156, 160, 166, 168, 171-173, 176, 178, 179  <b>11<sup>th</sup> grade:</b> 181, 182, 186, 188, 199, 201, 202, 212, 215, 231, 239, 243, 248, 250, 261, 263	<b>9<sup>th</sup> grade:</b> 6, 7, 9, 13, 18-20, 25, 26, 29, 31, 32, 41, 44, 61, 69, 70, 73, 74, 75, 79-82, 84, 87, 89, 81  <b>10<sup>th</sup> grade:</b> 94, 95, 106, 107, 110, 112, 113, 122, 124, 126, 128, 131, 132, 138, 139, 143-145, 151-153, 161-165, 170, 177, 180  <b>11<sup>th</sup> grade:</b> 184, 185, 187, 189, 190, 194-198, 200, 203, 204, 210, 211, 213, 216, 218, 220-223, 225-227, 230, 232-235, 240-142, 244, 247, 251, 252, 254, 256-260, 262, 265, 267, 269, 273	<b>9<sup>th</sup> grade:</b> 1, 3, 5, 8, 9-12, 14-17, 22-24, 27, 30, 33, 36, 37, 39, 40, 42, 43, 45, 47, 49, 51, 53, 55, 58, 59, 62, 64-66, 68, 71, 72, 86, 91  <b>10<sup>th</sup> grade:</b> 92, 93, 96-100, 104, 108, 111, 114, 115, 117-119, 121, 123, 125, 127, 129, 133-136, 141, 146, 147, 149, 150, 157-159, 167-169, 174, 175  <b>11<sup>th</sup> grade:</b> 183, 191-193, 205-209, 214, 217, 219, 224, 228, 229, 236, 237, 238, 245, 246, 249, 253, 255, 264, 266, 268, 270-272

## Conclusion

In general, the students from both Fifth Language School "Joan Exarch" and High School of Commerce "Georgi S. Rakovski" react with higher differentiability to the questionnaire and it makes it possible to analyze better different groups of attitude towards the educational issues. On contrary, the students from the High School of Mathematics reveal a strictly individual attitude towards the different

categories of questions and it does not allow strict grouping of both questions and students.

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