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Factor Analysis in Studies on Perception Difficulty of Options Chemistry Course Contents

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Abstract: This study aims at finding an answer to the question: what is the opinion / perception of prospective teachers of chemistry, that are currently in the development of initial training, the difficulty of specialized content that they will teach and whose attending? will be built future skills for their students. This pedagogical approach is supported by at least two goals of modern education focus on moving information in the formative dimension of the educational process, the full development of personality centering the educational action of the contents on the training skills to ensure the functioning knowledge of students procurement.

Keywords: Chemistry, Statistics.

Introduction

Taxonomy objectives were made during the development of behaviorism, in which the proposed of systematic voluntary (intentional) of natural and everyday learning situations have evolved. The critical support of behaviorists, in a paradoxically way says that such gains taxonomy "is too cerebral" (highlighted internal mental processes and observable

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behavior), instead just studying cognitive psychology internal processes and information processing leads to a more operational language course. Human Learning, an idea consistent with the views of Jerome Bruner (socio-cultural constructivist theory), is conducted at three levels: 1) the active way, made by the subject through action on world environment - sensory-motor intelligence stage, 2) the iconic way, based on visual organization and use of schematic or graphic images without the actual handling of Piaget's preoperational-stage, 3) the symbolic way, when the image place is taken by symbols, words or language formed, which allows for operators, rules training and transformation. The constructivist size states that to achieve an individual construction of knowledge implies that each individual constructs his individual knowledge through experiences lived in his environment. This general, theoretical perspective can circumvent some incompatibilities between National Curriculum in Chemistry (classes VII-XII) and planning undertaken by teachers, such as the gap between too strong emphasis placed on goals of generality medium (Classes VII-VIII) / general and specific skills (grades IX-XII) and the real possibility of breakdown by chapter content and themes. It is necessary to elaborate a coherent vision of a system of national standards for assessment of students on courses, curriculum areas, and subjects.

Finally, it should be taken into account certain characteristics of chemical education, such as quantity (volume of information circulated, which is considerably high), quality (the value of durability, reliability, efficiency of knowledge in the formative personality development), stability (lasting validity of knowledge), mobility (adapt science), diversification (representing the capacity of an information system to provide a large curriculum offer that is reflected in the training of various skills), specificity (chemical content that requires a specific information system, against a rich general culture. A direction which is manifested more strongly in recent years is also the environmental education, a field that involves many connections between the sciences (biology, physics, chemistry, geography, psychology, sociology), between social sectors (education, economics, industry, health). Without using data for all these instances, environmental education is not possible. Recommended curriculum for environmental education is based on common themes and objectives of several disciplines. It would be desirable minimum and systematic correlations made not only between related fields such as sciences, but also to identify related lines of environmental education with artistic disciplines (drawing, music, literature).

Why the main method applied was the design, implementation and operation results of a questionnaire? The questionnaire is a logical and psychological succession of questions, pictures and graphic symbols placed in architectural form, which is intended to determine human behavior on the subject in connection with obtaining information on a particular theme. The classification criteria of the typology of the questionnaire adopted in this study are:

-After the content we have factual data questionnaires and opinion surveys;

-After form of questions, we have questionnaires with closed questions, open questions, mixed questions;

-After the application of the questionnaire, we have questionnaires and self-administered questionnaires operators.

Why factor analysis? Because this is a collection of multivariate statistical methods, aimed at identifying the latent structure of a data set, describing a concept or a phenomenon characterized by a population of objects. In this study, the difficulty of the Chemistry content can not be captured in one variable, so it is not empirically observable. There are possible observable variables, measuring different aspects of the concept or phenomenon studied. Factor analysis allows understanding the structure of these variables in a concept or phenomenon and indicates its size.

Results and Discussions

Teaching Experiment

There were designed and implemented two surveys whose structure is given below, including the 16-item variables (VII.1-16, VII grade) and 9-item variables (VIII.1-9 for the VIII grade) with some modifications required by the accessibility of the questionnaire, the title content according to the existing curriculum and except items VIII.9 VIII.8 that have a browse content that is not according to the document pointed to VII class. Item VII.1 is not explicitly stated therein. The answerers of this questionnaire were 41 students of II and III year, of Chemistry Department. Data were processed using Excel and SPSS software, consisting in:

- presentation of descriptive statistics, in agreement with statistics literature, arithmetic mean, median, modal, standard deviation, skewness, kurtosis;
- presentation of histograms, presenting and explaining the results of factorial analysis.

"If you were a teacher of chemistry, what do you think that would be the difficulty of the concepts for the following units of content in seventh grade material (below the list of 16 items). For each of the items below, one response option, the registration number to the appropriate option in the summary sheet":

1	2	3	4	5
definitely easy	easy	so - so	difficult	definitely difficult

The list of 16 items, seventh grade:

1. Moments in chemical evolution as science.
2. Physical and chemical phenomena.
3. Homogeneous and heterogeneous mixtures. The separation of substances from mixtures.
4. Purification of substances by physical processes: distillation, extraction, sublimation. Solutions.
5. Concentration in mass percent.
6. Atom. Atomic nucleus. Atomic number. Mass number.
7. Chemical element. Chemical symbol.
8. Atomic mass.
9. Electron shell. Electron shell structure.
10. Regular system.
11. Valence. Molecules.
12. Chemical formulas. Molecular weight.
13. Law of conservation of mass of substances. Chemical equations.
14. Types of chemical reactions: combination reaction, decomposition, replacement and exchange.
15. Slow, fast, exothermic, endothermic reactions.
16. Stoechiometric calculations.

The list of 9 items, eighth grade:

1. Physical and chemical properties, the practical uses of nonmetals (hydrogen, oxygen, carbon, sulfur).

2. Physical and chemical properties, the practical uses of metals (aluminum, iron, copper).

3. Physical and chemical properties of oxides of non-metals.

4. Physical and chemical properties of metal oxides.

5. Acid strength.

6. Research of acid-base character of substances.

7. Physical and chemical properties of salts.

8. Organic substances for practical use. Hydrocarbons.

9. Functioned organic substances (alcohol, acetic acid, fat, protein saccharide).

Descriptive data and frequency histograms

Table 1. Descriptive Statistics VII grade, items 1-8

Statistics \ Item	1	2	3	4	5	6	7	8
Number of values	41	41	41	41	41	41	41	41
Average	2.17	2.29	2.63	3.17	2.44	2.22	2.29	2.27
Standard error of the average	0.152	0.106	0.143	0.152	0.156	0.146	0.141	0.135
Median	2.00	2.00	3.00	3.00	2.00	2.00	2.00	2.00
Modal	2	2	3	3	2	3	3	2
Standard deviation	0.972	0.680	0.915	0.972	1.001	0.936	0.901	0.867
Variation	0.945	0.462	0.838	0.945	1.002	0.876	0.812	0.751
Skewness	0.327	0.062	0.198	0.499	0.412	0.112	-0.199	0.405
Standard error of the skewness	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369
Kurtosis	-0.880	-0.066	0.065	-0.623	-0.218	-0.977	-1.059	-0.302
Standard error of the kurtosis	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724
Minimum value in sample	1	1	1	2	1	1	1	1
Maximum value in sample	4	4	5	5	5	4	4	4
Amount value	89	94	108	130	100	91	94	93

Table 2. Descriptive statistics seventh VII class, items 9-16

Statistics \ Item	9	10	11	12	13	14	15	16
Number of values	41	41	41	41	41	41	41	41
Average	2.49	2.83	2.95	2.93	3.71	3.78	3.85	3.90
Standard error of the average	0.131	0.144	0.139	0.118	0.122	0.138	0.124	0.159
Median	3.00	3.00	3.00	3.00	4.00	4.00	4.00	4.00
Modal	3	2	3	3	4	4	4	4
Standard deviation	0.840	0.919	0.893	0.755	0.782	0.881	0.792	1.020
Variation	0.706	0.845	0.798	0.570	0.612	0.776	0.628	1.040
Skewness	-0.624	0.356	-0.344	-0.610	-0.410	-0.467	-0.361	-0.986
Standard error of the skewness	0.369	0.369	0.369	0.369	0.369	0.369	0.369	0.369
Kurtosis	-0.509	-0.789	-0.785	0.643	0.045	-0.280	-0.091	0.629
Standard error of the kurtosis	0.724	0.724	0.724	0.724	0.724	0.724	0.724	0.724
Minimum value in sample	1	1	1	1	2	2	2	1
Maximum value in sample	4	5	4	4	5	5	5	5
Amount value	102	116	121	120	152	155	158	160

Table 3. Descriptive statistics VIII class, items 1-4

Statistics \ Item	1	2	3	4
Number of values	41	41	41	41
Average	2.32	2.71	3.05	3.20
Standard error of the average	0.137	0.149	0.144	0.127
Median	2.00	3.00	3.00	3.00
Modal	2(a)	3	3	3
Standard deviation	0.879	0.955	0.921	0.813
Variation	0.772	0.912	0.848	0.661
Skewness	0.012	0.092	-0.504	-0.381
Standard error of the skewness	0.369	0.369	0.369	0.369
Kurtosis	-0.726	-0.288	0.176	0.217
Standard error of the kurtosis	0.724	0.724	0.724	0.724
Minimum value in sample	1	1	1	1
Maximum value in sample	4	5	5	5
Amount value	95	111	125	131

Table 4. Descriptive Statistics VIII class, items 5-9

Statistics \ Item	5	6	7	8	9
Number of values	41	41	41	41	41
Average	3.39	3.56	3.32	3.24	3.73
Standard error of the average	0.156	0.148	0.154	0.159	0.168
Median	4.00	4.00	3.00	3.00	4.00
Modal	4	4	3	3	4
Standard deviation	0.997	0.950	0.986	1.019	1.073
Variation	0.994	0.902	0.972	1.039	1.151
Skewness	-0.397	-0.092	-0.364	-0.223	-0.833
Standard error of the skewness	0.369	0.369	0.369	0.369	0.369
Kurtosis	-0.530	-0.832	0.082	-0.284	0.419
Standard error of the kurtosis	0.724	0.724	0.724	0.724	0.724
Minimum value in sample	1	2	1	1	1
Maximum value in sample	5	5	5	5	5
Amount value	139	146	136	133	153

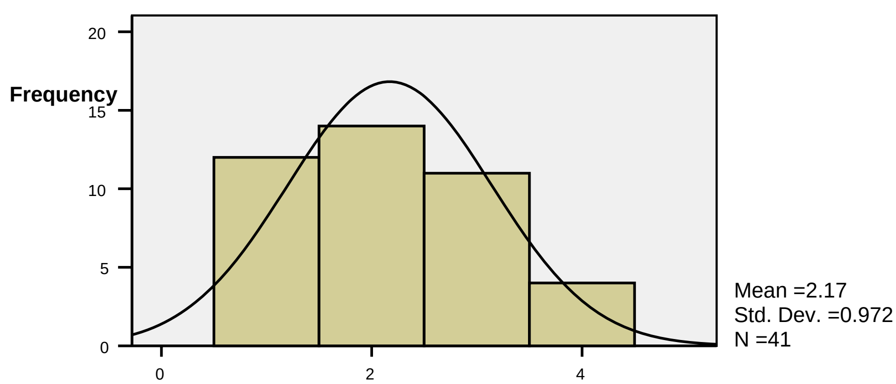

Figure 1. VII.1 - Histogram moments in the evolution of chemistry as a science.

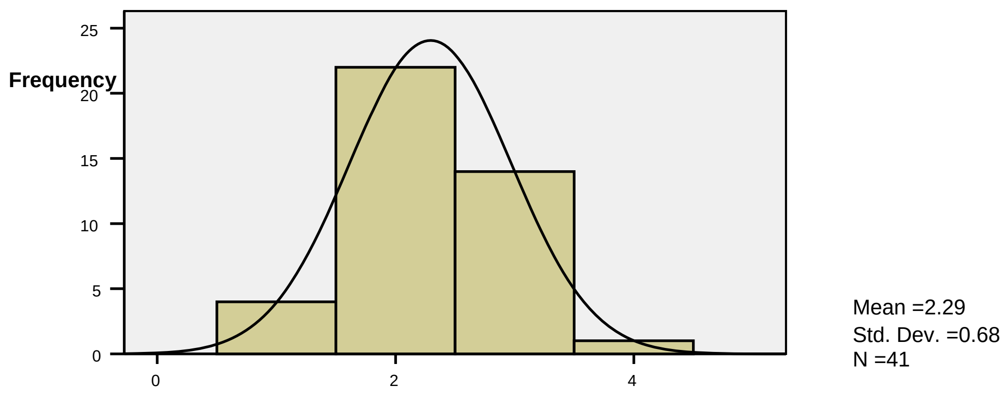

Figure 2. VII.2 - Histogram of physical and chemical phenomena.

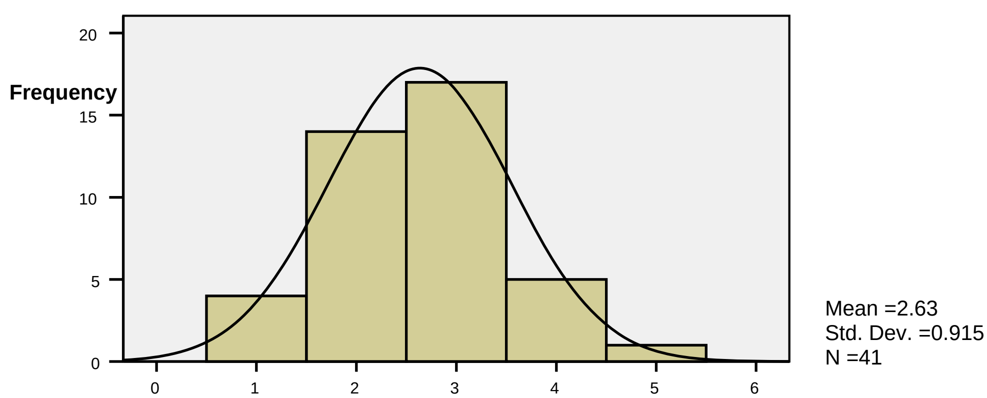

Figure 3. Histogram VII.3 - Homogeneous and heterogeneous mixtures. Separation of mixtures.

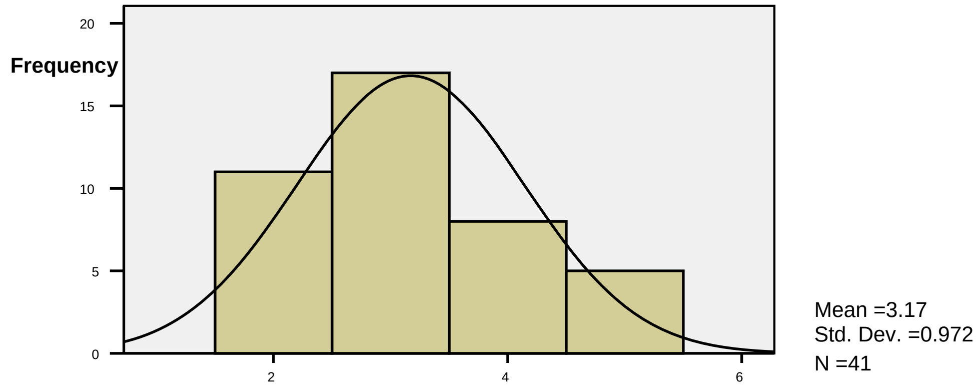

Figure 4. Histogram VII.4 - Purification of substances by physical processes: distillation, extraction, sublimation. Solutions.

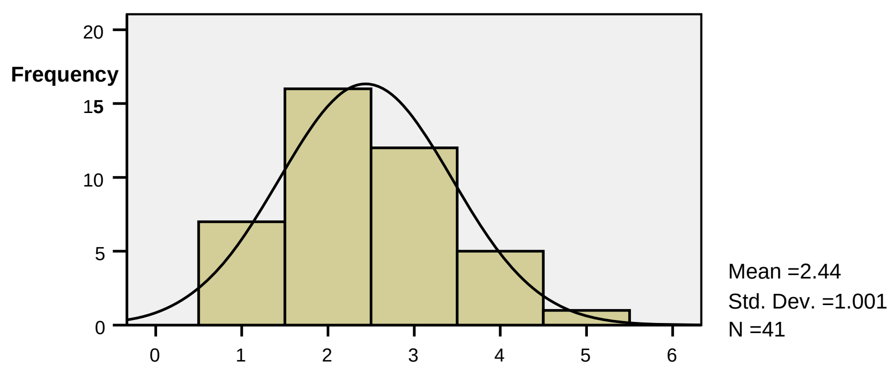

Figure 5. Histogram VII.5 - Percentage of the mass-concentration.

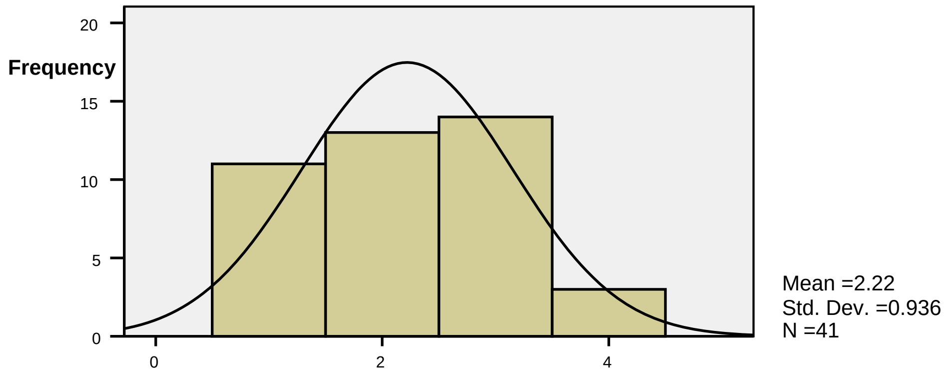

Figure 6. Histogram VII.6 - Atom. Atomic nucleus. Atomic number. Mass number.

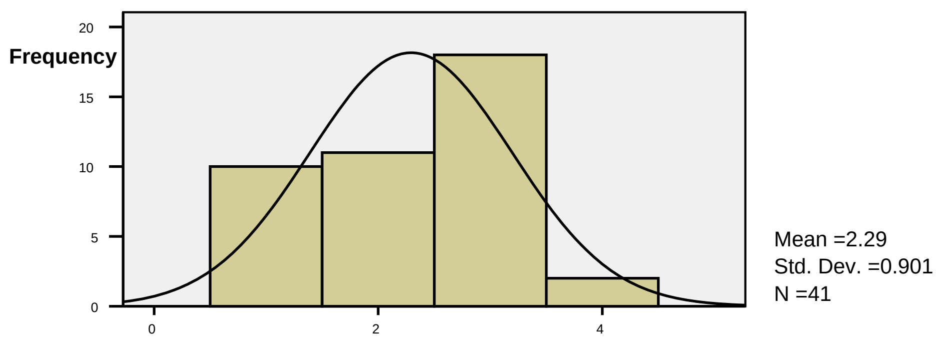

Figure 7. Histogram VII.7 - Chemical elements. Chemical symbol.

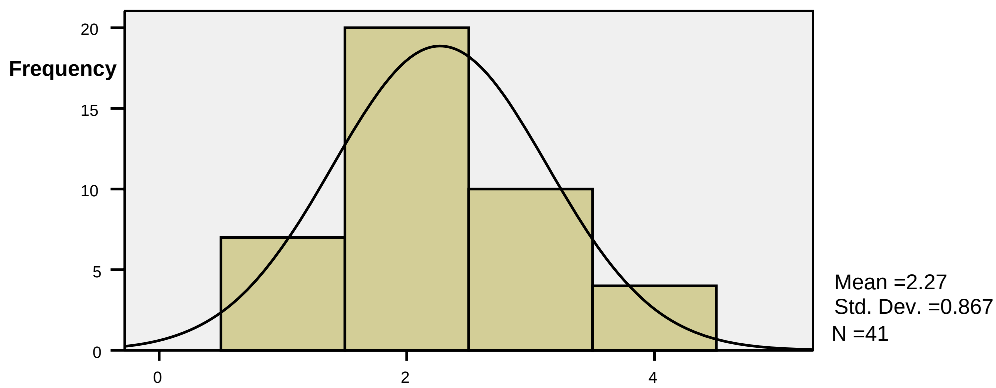

Figure 8. Histogram VII.8. - Atomic mass.

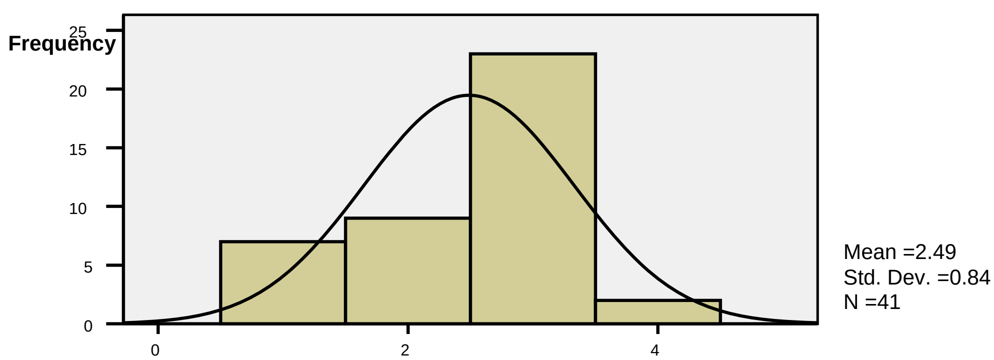

Figure 9. Histogram VII.9 - Shell electrons. Electron shell structure.

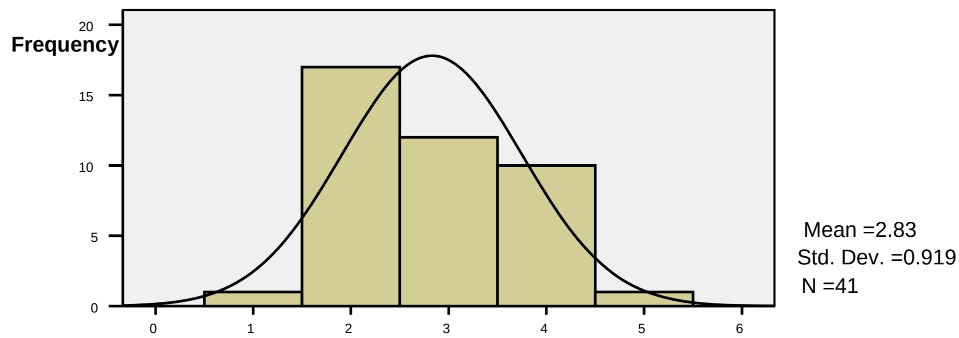

Figure 10. Histogram VII.10 - Regular system.

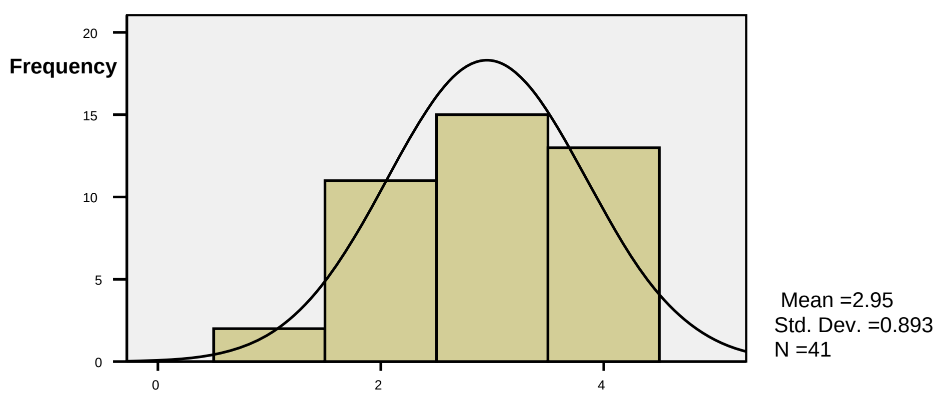

Figure 11. Histogram VII.11 - Valence. Molecules.

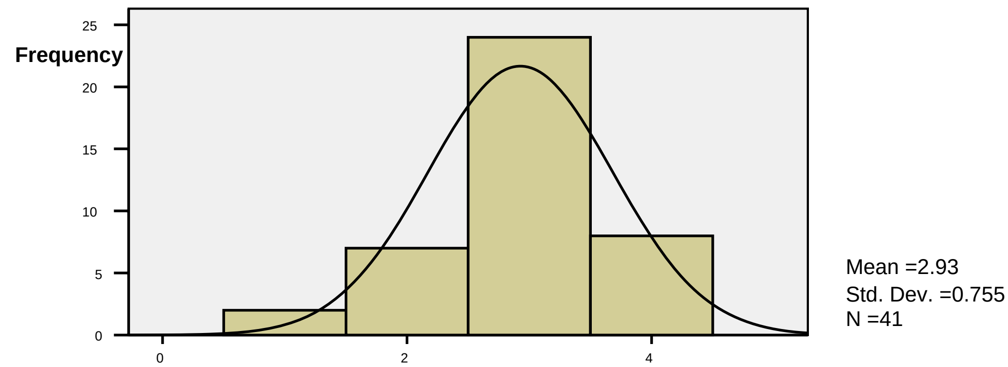

Figure 12. Histogram VII.12 - Chemical formulas. Molecular weight.

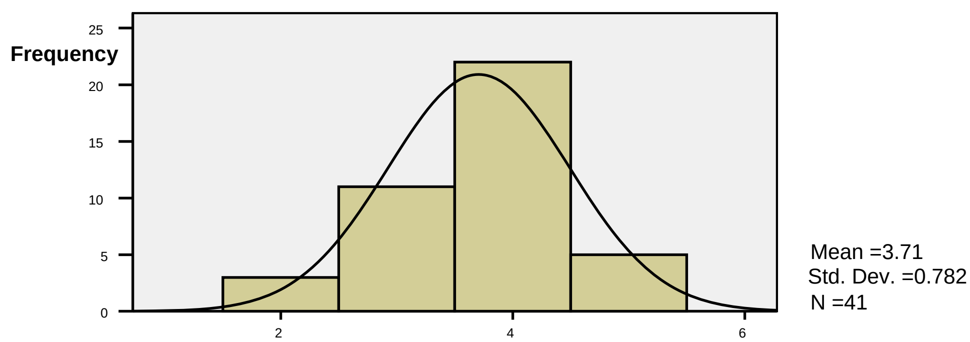

Figure 13. Histogram VII.13 - Law of conservation of mass substances. Chemical equations.

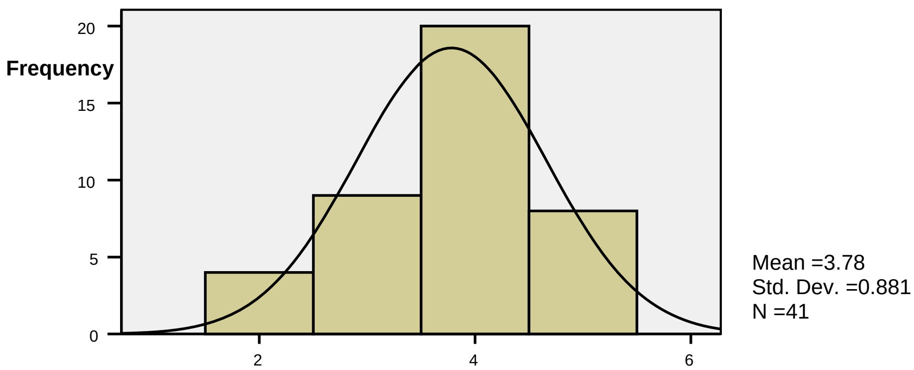

Figure 14. Histogram VII.14 - Types of chemical reactions: combination reaction, decomposition, replacement and exchange.

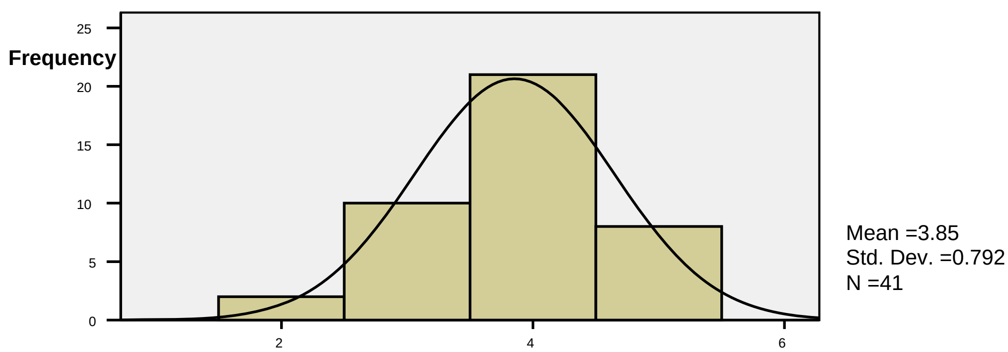

Figure 15. VII.15 - Side histogram slow, fast, exothermic, endothermic reactions.

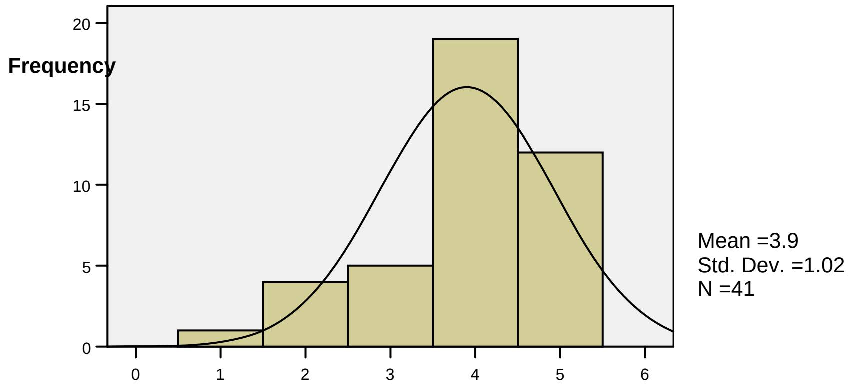

Figure 16. Histogram VII.16 - Stoichiometric calculations.

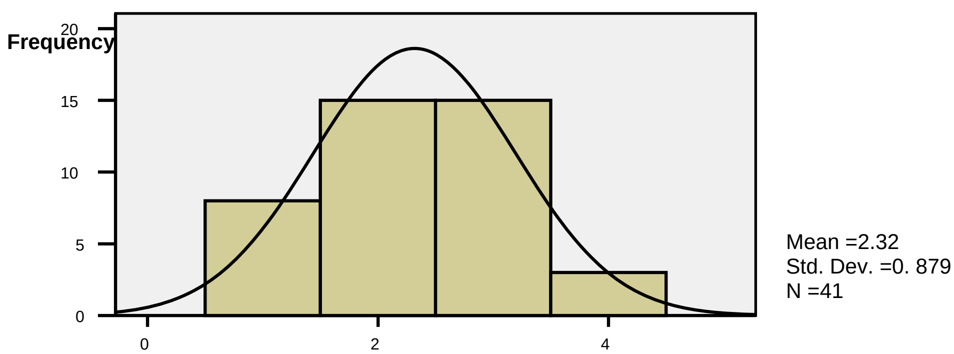

Figure 17. Histogram VIII.1 - Physical and chemical properties, the practical uses of nonmetals (hydrogen, oxygen, carbon, sulfur).

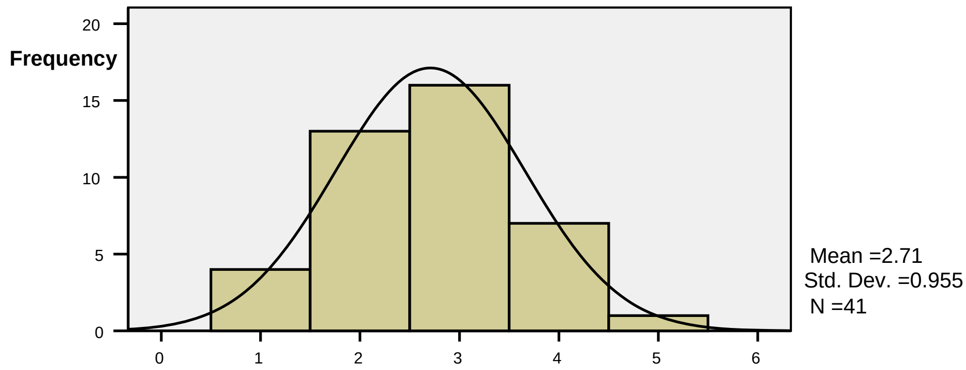

Figure 18. Histogram VIII.1 - Physical and chemical properties, the practical uses of metals (aluminum, iron, copper).

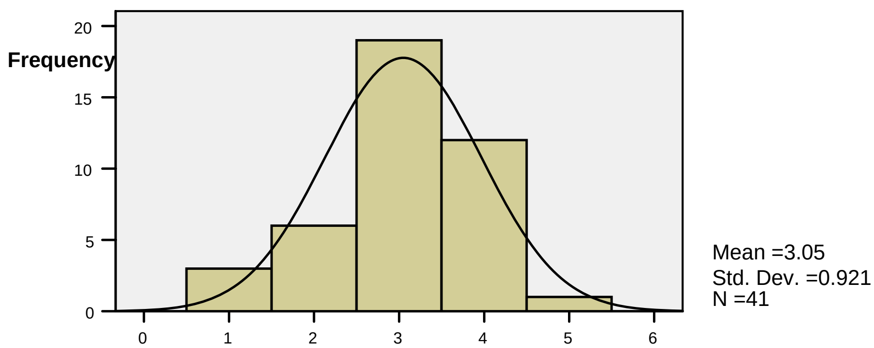

Figure 19. Histogram VIII.3 - Physical and chemical properties of oxides of non-metals.

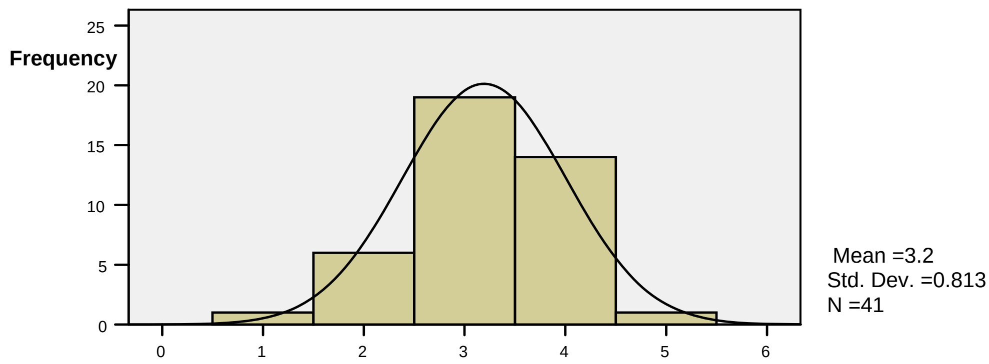

Figure 20. Histogram VIII.4 - Physical and chemical properties of metal oxides.

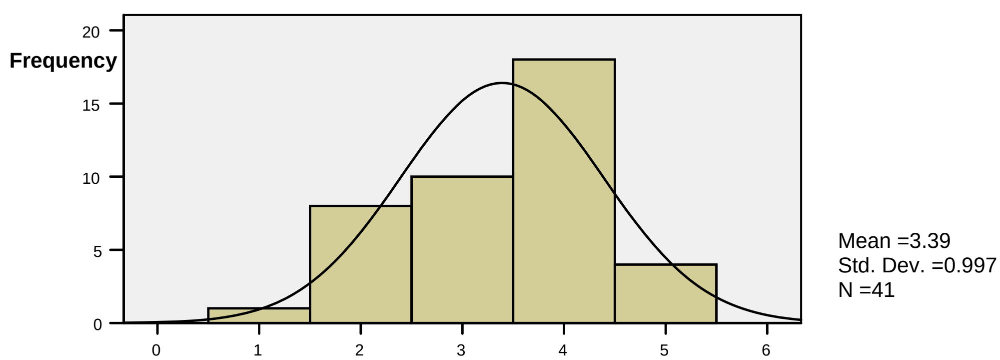

Figure 21. Histogram VIII.5 – Acid strength.

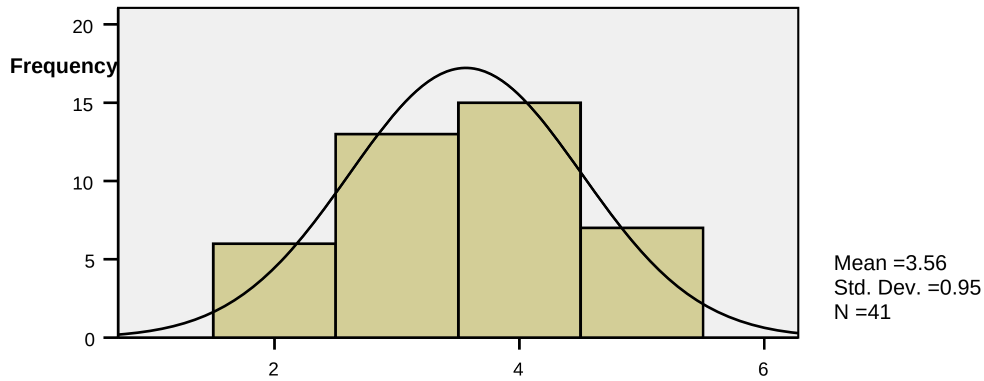

Figure 22. Histogram-Survey VIII.6 - Acid-base nature of some substances.

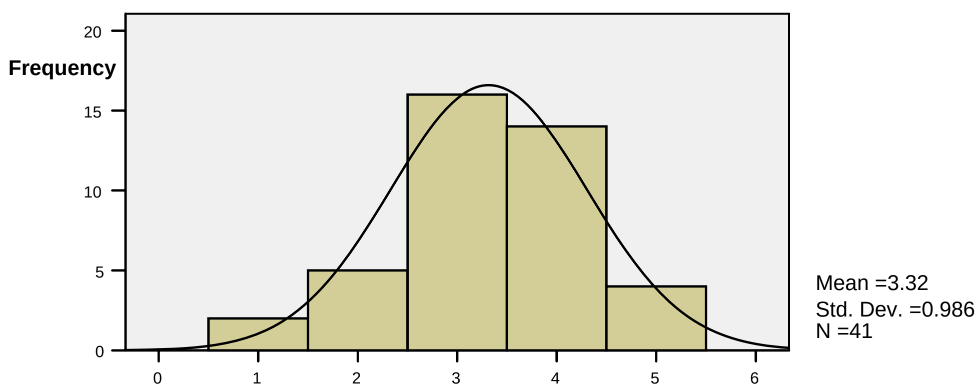

Figure 23. Histogram VIII.7 - Physical and chemical properties of salts.

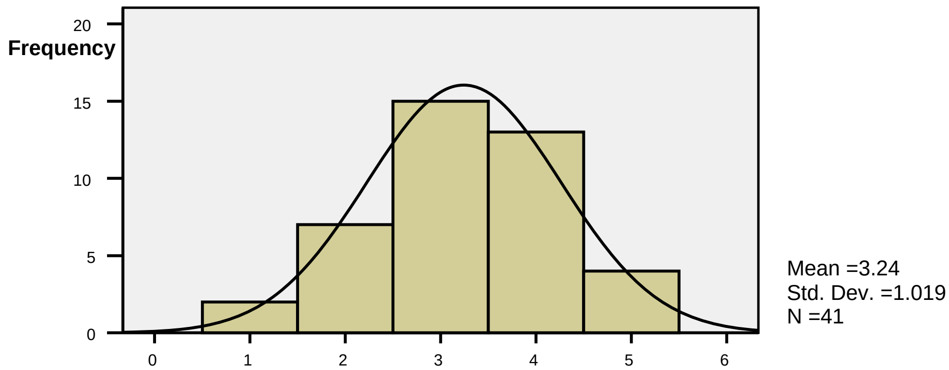

Figure 24. Histogram VIII.8 - Organic substances for practical use. Hydrocarbons

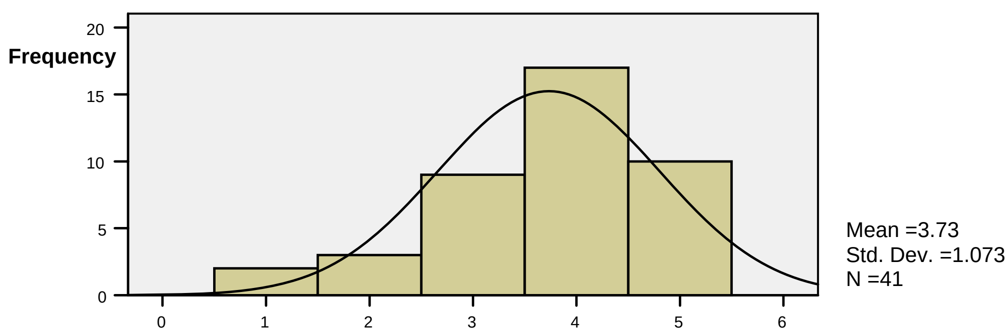

Figure 25. Histogram VIII.9 - Functionalised organic substances (alcohol, acetic acid, fat, protein, saccharide).

Partial conclusions from descriptive data and histogram shape

The 3-value modal, middle Likert-type scale, appears in 12 cases out of 25; such a high frequency is showing the hidden answer or simplified perception of discipline content.

- Minimum 2-value, *thus excluding the extreme facilities* appears for the items: Purification of substances, Substances law of mass conservation, Chemical reactions types, Slow, fast, exothermic, endothermic reactions, Acid-base character research. Interestingly, the same items are more likely and maximum five response options.

- The 4-modal, moved to higher odds of options (*high difficulty of content*), is for items: Law of conservation of mass substances, Chemical types of chemical reactions, Slow, fast, exothermic, endothermic reactions, Stoichiometric calculations. This reflects the opinion of most respondents about these levels, as the most difficult.

- For the following histograms, the modal value deviates significantly from other values of the histogram: *Histogram VII.8* - Atomic weight (obvious predominance of option 2), *Histogram VII.9* - Electrons shell. Shell electron structure, chemical formulas, *Histogram VII.12.* - Molecular (predominance of option three, somehow explained by the frequency with which respondents encountered this kind of application in everyday activity), *Histogram VII.14* - Types of chemical reactions: combination reaction, decomposition, replacement and exchange (predominance of option 4).

- The items perceived as difficult, with the exceptions stated above; the modal value is not deviating significantly from values close, so there is a wider perception of difficulty of the histogram. It is the case of *Histogram VII.16* - Stoichiometric calculations, *Histogram VIII.6* - The research of the acid –base character for some substances.

Factor analysis -The analyses of the principal components

In this study, we have 16 variables and we aimed at grouping them as new variables called "factors". Variable extraction and their old group will be made by **Principal Components Analysis (ACP), without rotation**.

First are assessed the opportunities for applying principal components analysis. Thus, to find a reason for the implementation of the ACP, we refer to the criteria of Coakes - at least five subjects per variable, or a sample of 100 subjects (accepted) or a sample of 200 subjects (preferably).

Values higher than 0.5 in the matrix of Pearson correlations, e.g. 0.3 show statistically significant links between variables. A positive value indicates values found for these direct links. Low values of coefficients in Table 1, are impossible to be given by the ACP application, because its purpose is to find correlations between variables. Since the Pearson matrix determinant value is less than 0.00001 (here 8.75 s -05) there are variables that strongly correlate with each other, so decreases the multicollinear probability. Multicollinearity refers to high correlations of over 0.80 between variables, which here appear in a considerable proportion. Variables found in such a situation should be eliminated, because they still can be found in the same factor.

We need to test the independence of the variables studied, which make the following assumptions:

1. H0: the assumption of independence, the correlation matrix is a unit matrix;
2. H1: the hypothesis of dependence.

For this, we use data in Table 5

Table 5. KMO test statistics and values of χ^2 statistics for the variable cl VII

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.624
Bartlett's Test of Sphericity	Approx. Chi-Square	316.137
	df	120
	Sig.	.000

Bartlett sphericity test result $\chi^2 = 316.137$, for a significance level of $p < 0.001$, shows that the matrix of correlations differs significantly from unity matrix, the variables should not correlate with each other, so variables are appropriate for factorization, therefore we accept the hypothesis H1.[3] Since after applying the ACP we'll get standardized variables, more exactly variables mean zero and a variance one, we'll have rendered the variances values of the new variable, which are presented in Table 6.

Table 6. The standardized variables variances.

Communalities		
	Initial	Extraction
Moments in chemical evolution as science	1.000	0.705
Physical and chemical phenomena	1.000	0.632
Homogeneous and heterogeneous mixtures	1.000	0.628
Purification of substances by physical processes	1.000	0.784
Concentration in mass percent	1.000	0.804
Atom. Atomic nucleus	1.000	0.809
Chemical element. Chemical symbol	1.000	0.834
Atomic mass	1.000	0.729
Electron shell. Electron shell structure	1.000	0.681
Regular system	1.000	0.545
Valence. Molecules	1.000	0.787
Chemical formulas. Molecular weight	1.000	0.755
Law of conservation of mass substances	1.000	0.756
Types of chemical reactions	1.000	0.821
Slow, fast, exothermic, endothermic reactions	1.000	0.643
Stoechiometric calculations	1.000	0.742
Extraction Method: Principal Component Analysis.		

The values in the column "Extraction" are presented in Table 6. These values are squared multiple correlation coefficients between variables and factors (R^2 from the multiple regression where the variable from the study is "the dependent variable”, and the extracted factors are "the independent variable").

There were extracted five factors with "eigenvalue" values higher than 1000, as Table 7 and Figure 26 confirms.

Table 7. Coordinates of the variables in the first five factorial axes.

Component Matrix(a)					
	Component				
	1	2	3	4	5
Types of chemical reactions	0.779	-0.407	-0.106	-0.195	-0.004
Chemical element. Chemical symbol	0.710	0.363	-0.143	-0.354	-0.229
Chemical formulas. Molecular weight	0.693	-0.296	0.079	0.394	-0.159
Electron shell. Electron shell structure	0.693	0.160	0.215	-0.212	-0.289
Atom. Atomic nucleus	0.637	0.552	-0.147	-0.048	-0.272
Reactions slow, fast, exothermic, endothermic	0.634	-0.407	0.115	0.099	0.226
Law of conservation of mass substances	0.587	-0.383	-0.312	-0.105	0.395
Regular system	0.561	-0.357	-0.019	0.068	-0.311
Stoechiometric calculations	0.542	-0.264	-0.327	0.274	0.444
Concentration in mass percent	0.289	0.712	-0.386	0.081	0.242
Atomic mass	0.351	0.546	-0.425	-0.285	0.214
Moments in chemical evolution as science	0.066	0.430	0.625	0.234	0.264
Purification of substances by physical processes	0.389	-0.381	0.577	-0.391	0.034
Homogeneous and heterogeneous mixtures	0.456	0.318	0.534	0.046	0.176
Physical and chemical phenomena	0.355	0.431	0.522	0.129	0.179
Valence. Molecules	0.373	0.143	-0.167	0.714	-0.299
Extraction Method: Principal Component Analysis (5 components extracted).					

Table 8. The values and their associated variance explained by each factorial axis.

Total Variance Explained									
	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %	Total	% Variance	Cumulative %
1	4.670	29.185	29.185	4.670	29.185	29.185	3.051	19.069	19.069
2	2.668	16.677	45.862	2.668	16.677	45.862	2.621	16.382	35.451
3	1.963	12.269	58.131	1.963	12.269	58.131	2.378	14.865	50.315
4	1.290	8.062	66.193	1.290	8.062	66.193	2.148	13.424	63.739
5	1.065	6.654	72.847	1.065	6.654	72.847	1.457	9.108	72.847
6	0.889	5.558	78.405						
7	0.675	4.219	82.624						
8	0.656	4.099	86.723						
9	0.546	3.411	90.134						
10	0.466	2.910	93.044						
11	0.300	1.876	94.920						
12	0.225	1.409	96.329						
13	0.212	1.325	97.655						
14	0.148	0.928	98.583						
15	0.139	0.866	99.449						
16	0.088	0.551	100.000						
Extraction Method: Principal Component Analysis.									

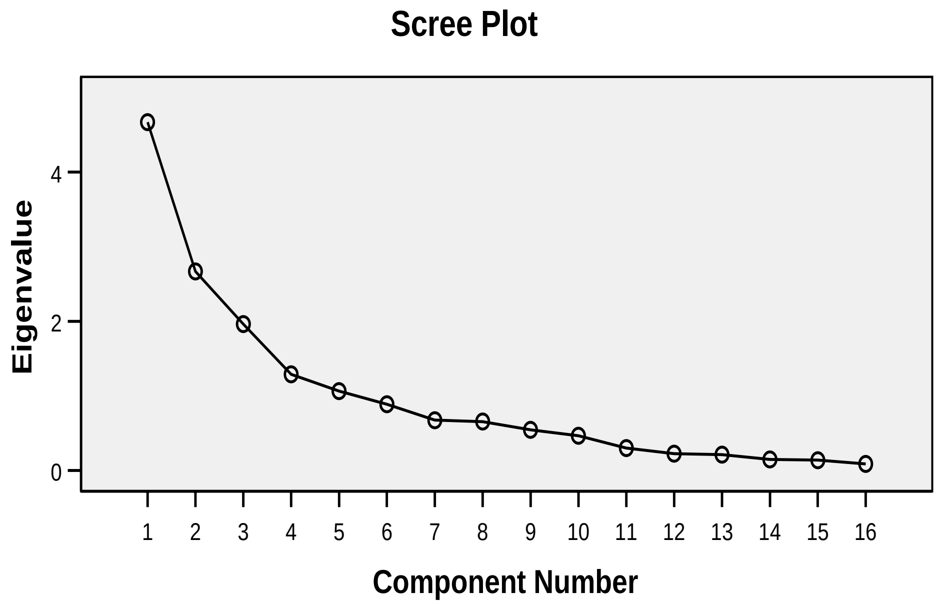

Figure 26. The graphical representation of the eigenvalues of correlation matrix (or "scree-plot” diagram).

Thus, the first factor explains 29.185% of variance of all items (variables, in this study), the second factor explains 16.677% of variance of all items, the third factor explains 12.299% of variance of all items, the fourth factor explains 8.062% of variance all items, the fifth factor explains 6.654% of the variance of all items and the five factors together explained 72.847% of variance extracted for all items. Significant difference between the fifth own value and the following (the value of "eigenvalue" $\lambda 5$ equal to 1.065 for the factor 5 compared to value "eigenvalue" $\lambda 6$ equal to 0.889 for factor 6) makes the first five factorial axes explain the largest differences between units statistics, in terms of response options expressed by respondents. We talk about the extraction of five factors note F1-F5. For example, variable “Chemical formulas. Molecular weight ", the variance after factor extraction, can be written as: σ Chimical formulas. Molecular weight = 0.6932 + (-0.296) 2 + 0.0792 + 0.3942 + (-0.159) 2, using the coordinates of the first five variables on factorial axis. The F1 factor will be "more consistent" in the variable "Types of chemical reactions," Chemical element. Chemical symbol", "Chemical formulas. Molecular weight", etc. The F2 factor will be "more consistent" in the variable “Concentration in mass percent, Atomic mass”, etc., in Table 7 - coordinates of the variables in the first five factorial axes.

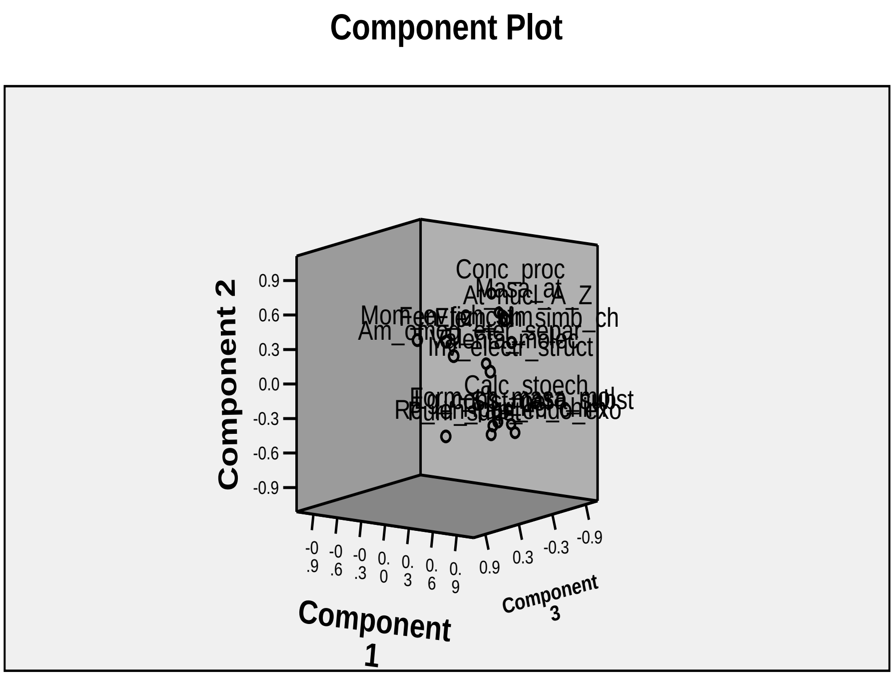

Figure 27. Representation in three-dimensional plane, the factorial solutions

ACP partial conclusion, the set of options VII grade

We have 16 variables that we wish to group them as new variables called "factors." Variable Extraction from their old variables group will be made by **principal components analysis (ACP), without rotation.**

- Variables are appropriate for factorization (KMO, check **multicollinear** - it doesn't exist variables that can correlate strongly with each other, so decreases the likelihood **multicollinear**).

- Five factors of the 16 variables were extracted with "eigenvalue" higher than 1.000, The first factor explains 29.185% of variance of all items, the second factor explains 16.677% of variance all items, the third factor explains 12.299% of the variance for all items, the fourth factor explains 8.062% of the variance for all items, the fifth factor explains 6.654% of the variance for all items, and together the five extracted factors explain 72.847% of the variance for all items.

- The factor F1 will be "more consistent" in the variable "Types of chemical reactions", "Chemical element. Chemical symbol", "Chemical formulas. Molecular weight", etc.; F2 factor is "more consistent" in the variable "Concentration in mass percent. Atomic mass", etc., in Table 7 - coordinates of the variables in the first five factorial axes.

Conclusions

Partial conclusions from descriptive data and histogram shape:

The three-modal, middle Likert-type scale, appears in 12 cases out of 25, such a high frequency of the no answer shows hidden or simplified perception of discipline content. The 2 minimum values, *thus excluding the extreme facilities* appear in these items: Purification of substances, The conservation law of mass substances, Chemical reactions (slow, fast, exothermic, endothermic), Acid-base character research. Interestingly, the same item is more likely and maximum five response options.

The four-modal, moved to higher odds of options (high difficulty of content), appears for items: The conservation law of mass substances, Chemical reactions (slow, fast, exothermic, endothermic), Stoechiometric calculations. This reflects the opinion of most respondents about these levels, as the most difficult.

For the following histograms, the modal value deviates significantly from other values of the histogram: Histogram VII.8 - Atomic weight (clear predominance of option 2), Histogram VII.9 - Shell electron, shell electron structure, chemical formulas, Histogram VII.12 – Chemical formulas (clear predominance of option three, somehow explained by the frequency with which respondents encountered this kind of application in everyday activity), Histogram VII.14 - Types of chemical reactions: combination reaction, decomposition, replacement and exchange (clear predominance of option 4).

The items perceived as difficult, with the exceptions stated above, the modal value not deviating significantly from close values, so there is a wider perception of difficulty. Histogram VII.16 - Stoichiometric calculations, histograms VIII.6 - Acid-base character of some substances.

ACP partial conclusion, the set of options VII grade

We have grouped 16 variables as new variables called "factors." Variables were extracted from their old group by **principal components analysis (ACP), without rotation**.

Variables are appropriate for factorization (KMO, check multicollinear - no variables that correlate strongly with each other, so decreases the multicolinear probability).

Of the 16 variables, five factors were extracted with "eigenvalue" higher than 1000. The first factor explains 29.185% of variance of all items, the second factor explains 16.677% of variance all items, the third factor explains 12.299% of the variance for all items, the fourth factor explains 8.062% of the variance for all items, the fifth factor explains 6.654% of the variance for all items, and together the five extracted factors explain 72.847% of the variance for all items.

F1 factor is "more consistent" in the variable "Types of chemical reactions", "Chemical element. Chemical symbol", "Chemical formulas. Molecular weight", etc., F2 factor is more consistent in the variable "Concentration in mass percent", "Atomic mass".

References

1. Cozma, D. G. and Pui, A., "*Teaching Chemistry - Theory and Applications*", Performance, Science, 2009.
2. Culic, I., "*Advanced Methods in social research, multivariate analysis of interdependence*", Polirom, Iasi, 2004.
3. Fatu, S., "*Teaching Chemistry*", Corinth, Bucharest, 2002.
4. Frumos, F., "*Teaching - Fundamentals and cognitiviste development*", Collection Sciences Education, Polirom, Iasi, 2008.
5. Howitt, D. and Cramer, D., "*Introduction to SPSS for Psychology*", Polirom, Iasi, 2006.

6. Jaba, E., "*Statistics*", 3td Ed., Economic Publishing House, Bucharest, 2002.
7. Jemna, D. V., "*Efficiency statistical survey*", Sedcom Libris, Iasi, 2005.
8. Labăr , A. V., "*SPSS for science education*", Polirom, Iasi, 2008.
9. Ministry of Education and Research, revised curriculum, grades VII - VIII, Bucharest, 2008, approved by OMECT 4875 / 07.22.2008.
10. Naumescu, A. and Bocos, M., "*Teaching Chemistry from theory to practice*", Educational Sciences Collection, Publishing House of Science Books, Cluj-Napoca, 2004.