DE GRUYTER
OPEN

ACTA CHEMICA IASI, **22_1**, 39-56 (2014)
DOI: 10.2478/achi-2014-0004

Correlations among various factors influencing learning of chemistry

Liliana Lemnaru[a], Mihaela Pui[b], Danut-Gabriel Cozma[c*]

[a]*Prisacani School, County of Iasi*

[b]*"Otilia Cazimir" School, Iasi*

[c]*"Al. I. Cuza" University of Iasi, Faculty of Chemistry 11, Carol I Bd Iasi 700506, Romania*

Abstract: Modern education focuses the didactic discourse on learning (namely, on the development of an" instructive paradigm"), on the more intensely manifested need of orienting didactics towards competence, the pupil being viewed as the subject of his/her own accomplishment. The present study analyzes the correlations occurring among the various factors known as influencing the learning and the results of learning Chemistry, from two different perspectives: the psychopaedagogical realities of early adolescence and the inherent difficulties characteristic to a most special scientific discipline (Chemistry). The observation made is that several factors – such as the specific contents of the discipline, the age of the pupils, their family background, participation to extra-curricular activities – may positively influence the didactic process, while a precarious family condition and avoidance of extra-curricular involvement may negatively affect learning.

Introduction

Human learning means the transfer of knowledge, which involves establishment of general objectives (to be achieved on long-term, in the end of a school cycle), as well as of intermediary ones (achievable on average-term, not more than one year), from which the operational objectives are

* Danut-Gabriel Cozma, *e-mail*: dcozma@uaic.ro

subsequently derived. With reference to the last ones – which also opens the way to the topic of the present study - pedagogic literature states that not any objective may become operational. Stating of the performance criterion, intrinsic to any operational objective, is not sufficient for accomplishing a lesson, another criterion, namely that of competence, being also necessary.[1] The objectives of the investigation evidence, in operational terms, the specific influence of parameters: age and mental development, characterizing the students involved in the study. By its very nature, Chemistry involves specific relations with related disciplines, which makes necessary recourse to interdisciplinarity. Interdisciplinarity may be defined as a transfer of concepts, methods and educational strategies applicable from one discipline to another, structured on two different levels: an applicative one, assuming the transfer of methods through which practical, concrete applications may be realized, and an epistemological one, permitting a successful assimilation, in chemistry, of methods, contents and strategies belonging to other scientific domains. The notions of epistemological nature - such as the concept of structure of matter, scientific judgement, unitary reasoning etc. – permit an operational transfer.[2] A correct definition of the issue had in view in the present study may represent a reasonable way for attaining interdisciplinarity. Apart from the traditional methods, a precise statement of the problem to be solved challenges pupil's thinking, favourizes connections among phenomena, extends reflection and the intellectual capacity. Involving the idea of personal creativity (euristics), from which the method of definition is actually derived, it endows the pupil with the capacity of grasping the existence / non-existence of any unknown quantity, considered versus his level of knowledge, and also the manner of its setting forth. The possible modalities available for solving such a problematic situation include: recommending additional materials for finding solutions, selection of useful information, establishment of a predominantly heuristic strategy for finding out optimal solutions.[3] Motivation remains a key-element of learning, with reference to the traditional approaching of intrinsic motivation, formally opposed to the extrinsic one.[4] Intrinsic motivation includes ”the motivation to know”, ”the motivation to do / to achieve something”, ”the motivation for an active existence”. From the perspective of extrinsic motivation, pupil’s availability is considered as a means for attaining one’s scopes. Extrinsic motivation is based on certain regulation mechanisms: rewards and constraints, partial assuming of the motifs of one’s own actions, even if this is not a self-determined initiative, once external elements are here involved.[5] Motivation is a variable whose two aspects (intrinsic / extrinsic) occur in various ratios, the idea of learning activities based exclusively on intrinsic motivation being wholly unrealistic.[4] The factors of creativity have been also monitorized independently on the concept of interdisciplinarity, on outlining the influence of the profiles or channels of preuniversity training (gymnasium - not differentiated on specializations; secondary school – theoretical and scientific specialization; secondary school – theoretical and humanistic specialization; secondary school – vocational profiles, art) upon certain characteristics of creativity (fluidity, flexibility and originality).[6] In this respect, mention may be therefore made of the so-called ”pillars of learning”,[2] synthetically expressed in the following conceptual formulations: learning to learn, more exactly to know, to understand the instruments of knowledge; learning to do, which assumes that the subject of learning assimilates the necessary skills for practising a certain profession, being capable of taking decisions in various situations he is confronted with in everyday life, makes use of advanced technologies, is actively involved in improving the qualitaty of his personal and social life; learning to work in group: the subject of learning is prepared for team work, viewed as a necessary condition for preventing and solving conflicts, for attaining the common objectives proposed, while having regard for each member's identity, for actively participating to the life of the community, for establishing a healthy and happy family, etc.; learning to be: development of one's personality for becoming capable of acting independently and creatively in certain situations, having a critical and responsible thinking, manifesting aesthetic propensity, acting for maintaing a peaceful and pleasant social climate; learning to be transformed and to change the society:[7] the necessary transformation of one's own attitude for having a correct knowledge, understanding and action upon the surrounding reality, environment's protection, favourizing social cohesion and a non-discriminating society. Learning in itself would be difficult to address without capitalizing additional information provided by other disciplines, realted to Chemistry. Interdisciplinarity is associated, to a considerable extent, with creativity.

The present study aims at establishing a correlation among the various factors which influence learning, such as: the content of the discipline, pupils' age, family background, participation to extracurricular activities, results.

Research protocol

The objective of the investigation was to identify the possible influences, of both economico-social and formal-organizational nature, upon the manner in which interdisciplinarity is understood by gymnasium pupils from a gymnasium school of Iaşi county (Romania). Processing of statistical data made use of a SPSS 14 software application.[8,7]

The study was developed on a group of 18 gymnasium pupils investigated along 2 consecutive school years. Among the school documents that might offer data of paedagogic significance for the present research, mention should be made of: 1) the evaluation tests on OXIDES, including interdisciplinary items, administered to the 8th form pupils during the second term; 2) class teacher's notes; 3) the personal notations of the chemistry teacher; 4) school rolls of the 7th form pupils in the years 2010-2011 and 2011- 2012, respectively; 5) the file of the person responsible with educative activities and projects in the school; 6) the file of the ”Mathematics and sciences of nature” methodic commission from the education unit in which the investigation was performed.

The test was realized and administered in the second term of class 8th, on a sample group of pupils monitorized twice a year (along two consecutive school years). It includes 6 items, with a solving time of one hour (effective time: 45 min); the first 5 themes were deliberatedly monodisciplinary issues, while the last one was an interdisciplinary one.[10]

Evaluation test - OXIDES
Discipline: Chemistry
Class: VIIIth

Name and first name of the pupil: ....
Data of test: ....

- Correct solving of all items presented in Parts I and II - 9 points (1 point *ex officio*).
- Effective working time: 45 minutes.

Part I 4 points

1. Read carefully the information below. If you consider the assertion true, encircle letter A, if you find it false, encircle letter F.

A F a) Certain acid oxides react with water, giving acids.
A F b) Carbon dioxide, CO_2, contributes, together with other gases, to the greenhouse effect.
A F c) At normal temperature, oxides occur in solid, liquid and gaseous form.
A F d) Calcium oxide, CaO - slaked lime - is utilized in building industries.

(4 x 0.25p = 1p)

2. Fill in the voids of the assertions below:

a) The binary compounds of oxygen with .... or .... are called oxides.
b) The non-metallic oxides are also called .... as, when reacting with water, they form ....
c) The oxides of metals are also called .... as, when reacting with water, they form ....

d) Dissolution of carbon dioxide, CO_2, in water gives ...., also known as ....

(4 x 0.25p = 1p)

3. Associate to each oxide listed in column A an utilization from column B.

A	B
1) Aluminium oxide, Al_2O_3	a) Gas involved in photosynthesis
2) Titanium dioxide	b) Semi-precious stones
3) Sulphur dioxide, SO_2	c) Pigment
4) Carbon dioxide, CO_2	d) Selective solvent of oil refining

1	2	3	4

(4 x 0.25p = 1p)

4. Propose 2 methods for obtaining the following oxides:
a) copper oxide;
b) sulphur dioxide.

(4 x 0.25p = 1p)

Part II 5 points

5. Consider the following scheme-program:

$$A \rightarrow a + b\uparrow$$
$$a + H_2O \rightarrow c$$
$$b + c = A\downarrow + H_2O$$
$$b + C \text{ (carbon)} \rightarrow d$$

Substance A contains 40% Ca, 12% C and 48% O (expressed as mass percent ratios).

a) Identify the substances denoted by letters.
b) Write down the equations of the chemical reactions represented in the above scheme.
c) Indicate the type of chemical reactions.

(a- 0.6p; b- 1p, c- 0.4p = 2p)

6. 10 Kg of anthracite, with a caloric power of $35.35 \cdot 10^3$ KJ/Kg are burned. Determine:

a) The amount of heat released through burning.
b) The amount of carbon dioxide obtained (in grams and moles).
c) Considering that half of the obtained amount of carbon dioxide is bubbled in lime water, determine the obtained amount of precipitate.

It is consided that anthracite contains 95% carbon.

(3 x 1p = 3p)

Given: $A_{Ca} = 40$; $A_C = 12$; $A_O = 16$ and $A_H = 1$.

Results and discussion

The paedagogic investigation was developed for checking the hypothesis according to which gymnasium pupils have difficulties when working with the novel coordinates of interdisciplinarity, comparatively with the so-called more accessible monodisciplinary perspective. Also considered was the influence of the type of family, as an independent variable, upon the mark obtained in the docimological test. The interdisciplinary item (the 6th in the structure of the docimological test) appeals to information provided by disciplines Physics, 6th and 7th classes, grafted on that of 7th class Chemistry, once known that class 8th represents the age level and chronological moment at which administration of the docimological test should be done.

In the present study, the idea of monitorizing the effects of interdisciplinarity by means of a docimological test introduces two independent variables: the annual average registered at chemistry in class 7th, noted as Av_7, respectively the semester average at chemistry of the same pupils, in class 8th, term I, noted as Av_8, and a dependent variable, the mark of the docimological interdisciplinary test, noted as Av_dcm, whose correlation is graphically plotted in Figure 1.

The chronological order of the 3 variables is: Av_7; Av_8; Av_dcm. On the whole, the marks obtained in the interdisciplinary Av_dcm test are correlated with the Av_7 and Av_8 media, namely the low values of variables Av_7 and Av_8 (situated in the upper zones of the horizontal squares) are associated with the low values of variable Av_dcm, a similar aspect being also observable for the large domain of the same variables.

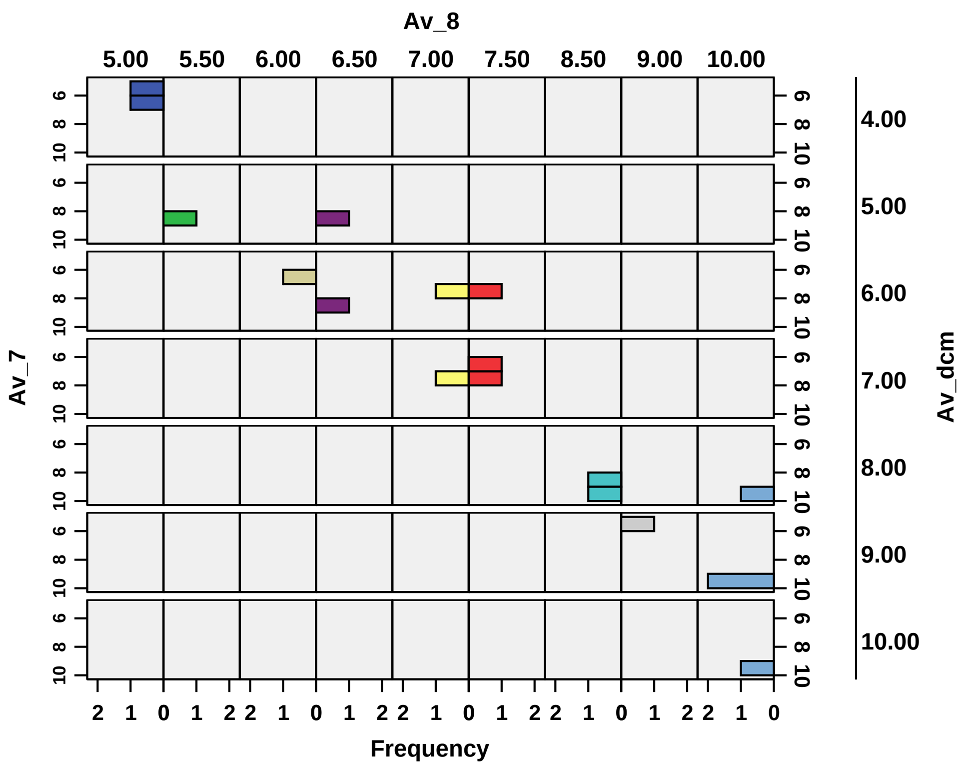

Figure 1. Graphical representation of the dependence of docimological test results (Av_dcm) on the annual average at chemistry in the 7th class (Av_7) and of the average of first term, 8th class (Av_8), respectively.

No extreme ("outliers") values are observed, which indicates the increased homogeneity of the group of pupils, as they progress with the acquisition of new cognitive competences, along the inherent maturation they experience during their school years.

Further on, the relation between the two categories of total evaluation, Av_7 and Av_8, and the mark of the docimological test Av_dcm is investigated, by means of Wilcoxon test. The starting point is the assumption according to which such heterogeneous evaluations (semester/annual average), which ”combine” several variables quite difficult to rigorously quantify, should permit a certain predictibility of the behaviours evidenced by the pupils forming the experimental group during the learning process. Wilcoxon test was preferred due to the existence of two (variable) pair sample groups, both of them of quantitative nature and reduced volume. [11,12]

Application of Wilcoxon test[11,12] between two aleatory variables requires ”variable-score” or ”quantitative variable” characteristics from their part, and also their distribution at sufficient distance from the Gauss-Laplace (or normal) distribution, whereas the samples giving expression to these variables should have a low volume. Interpretation of the results of Wilcoxon text includes references to the standard variable Z,[13] to be identified, for any aleatory variable subjected to standardization, with relation:

$$z = \frac{x - \mu}{\sigma} \tag{1}$$

where x = the values of the random variable to be normed; μ = arithmetical mean associated to the random variable to be normed; σ = standard deviation of the random variable to be normed. If the value of the significance level of the Wilcoxon text (conventionally denominated as ”Asymp. Sig. (2-tailed)”) is lower than the value of the risk coefficient accepted in literature (conventionally denominated as α and having a standard value 0.05),[11-13] then the Wilcoxon test is statistically significant.

The results of Wilcoxon test’s application between the random Av_7 and Avdcm variables are listed in tables 1 and 2.

Table 1. Ranks resulted from the application of Wilcoxon test.

Pairs of variables		N	Mean Rank	Sum of Ranks
Av_dcm-Av_7	Negative Ranks	15a	8.00	120.00
	Positive Ranks	0b	0.00	0.00
	Ties/ Equal values of the variables	3c		
	Total	18		

a. Av_dcm < Av_7; b. Av_dcm > Av_7; c. Av_dcm = Av_7

The symbols used in table 1, including the average of ranks, the sum of ranks and the number of subjects for each of the 3 situations considered for comparative purposes, are the following: negative ranks, in which the rank of variable Av_dcm is lower than that of variable Av_7; positive ranks, in which the rank of variable Av_dcm is higher than that of variable Av_7; ”ties” or the cases of equality, in which the rank of variable Av_dcm is equal to that of variable Av_7.

Table 2 lists the value of statistics Z for Wilcoxon test (the normed variable being obtained from the difference of ranks of the Av_dcm, respectively Av_7 random variables) and of the significance level of Wilcoxon test.

Table 2. Wilcoxon Test Statisticsa.

Indices	Av_dcm – Av_7
Z	-3.453b
Asymp. Sig. (2-tailed)	0.001

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks

Significant differences appear between the two variables ($Z = -3.453$, two-tailed $p = 0.001$). To estimate the meaning of such differences, one should consider the highest sum of ranks indicated by the values listed in table 1, column ”Sum of Ranks”. In the case of the relation between Av_dcm and Av_7, it corresponds to the negative ranks, namely to the situations in which the rank of variable Av_dcm is lower than that of variable Av_7. Consequently, variable Av_dcm provided lower values than variable Av_7.

Such a result might be explained by pupils’ maturation, combined with the effects of the didactic teaching-learning activity at Chemistry discipline. The process of maturation, gradually installed starting with the age of 14 years (corresponding to class 7th), as well as the stepwise introduction of difficult chemistry notions in the two gymnasium forms in which this discipline is taught, required the administration of the test with interdisciplinary reasoning (class 8th). The 14-16 age interval is characterized by logical and formal consolidation, more obvious in the case of mathematics and natural sciences. Equally, life at this age is emotionally less "alarming" than usually described by the synthetic stereotypical expression "storm and stress", frequently associated with this teen-age period.[14]

The results of Wilcoxon test's application between the random variables Av_8 and Av_dcm, by repeating the procedure used when Wilcoxon test was applied between variables Av_7 and Av_dcm, are given in tables 3 and 4.

Table 3. Ranks resulting from the application of Wilcoxon test.

Pairs of variables		N	Mean Rank	Sum of Ranks
Av_dcm-Av_7	Negative Ranks /	14a	7.50	105.00
	Positive Ranks/	0b	0.00	0.00
	Ties / Equal values of variables	4c		
	Total	18		

a. Av_dcm < Av_7; b. Av_dcm > Av_7; c. Av_dcm = Av_7

Similarly with the already-mentioned case, 3 comparable situations may be identified: negative ranks, in which the rank of variable Av_dcm is lower than the rank of variable Av_8; positive ranks, in which the rank of variable Av_dcm ist higher than that of variable Av_8; ”ties” or equal situations, in which the rank of variable Av_dcm is equal with that of variable Av_8.

Table 4. Wilcoxon / Test Statisticsa.

Indices	Av_dcm – Av_8
Z	-3.342b
Asymp. Sig. (2-tailed)	0.001

a. Wilcoxon Signed Ranks Test
b. Based on positive ranks

Significant differences may be observed between the two variables (Z = -3.342, two-tailed p = 0.001). To estimate their meaning, the highest sum of ranks indicated by the values from table 1, column ”Sum of Ranks”, will be considered in the analysis. In the case of the Av_dcm *vs* Av_8 relation, this corresponds to negative ranks, namely to the situations in which the rank of variable Av_dcm is lower than that of variable Av_8. Consequently, variable Av_dcm provided lower values than variable Av_8. Similarly with variable Av_7, variable Av_8 recorded higher values than variable Av_dcm.

Therefore, whichever the age (once known that the ages of pupils from the two gymnasium classes are quite similar), the interdisciplinary test was quite difficult for the pupils, more precisely it generated lower scores (marks) than those registered for the total evaluations expressed by variables Av_7 and Av_8.

Analysis of Spearman correlation[11,12] among the items to be solved in the test is necessary for measuring the validity of the assertion according to which the interdisciplinary item would be compulsory for pupils with a different learning behaviour than the traditional, monodisciplinary one.

Table 5. Spearman Rank Order Correlations.

Variable	Av_7	Av_8	Av_dcm
Av_7	1.00	0.97	0.94
Av_8	0.97	1.00	0.94
Av_dcm	0.94	0.94	1.00

Marked correlations are statistically significant at a risk threshold = 0.05.

Correlation analysis of the marks / scores obtained for the 5 items of the interdisciplinary test, conventionally considered as monodisciplinary, and also for issue 6, conventionally considered as interdisciplinary, is based on the values of the correlation coefficient of the Spearman ranks presented in table 5. Without aiming at developing a consistent internal analysis of the docimological test, attempts were made for performing a non-parametric Spearman correlation analysis (as the scales for each issue are not identical, being equivalent to the standard scale applied in Romania, ranging between 1 and 10).

Table 6. Non-parametric Spearman correlations among pair variables.

Pairs of Variables	Valid – N Number of values	Value of Spearman – R coefficient	Significance p-level
Item_1 & Item_3	18	0.57	0.01
Item_1 & Item_5	18	0.53	0.02
Item_1 & Item_int	18	0.62	0.00
Item_2 & Item_4	18	0.51	0.02
Item_2 & Item_int	18	0.57	0.01
Item_3 & Item_4	18	0.65	0.00
Item_4 & Item_2	18	0.51	0.02
Item_4 & Item_3	18	0.65	0.00
Item_5 & Item_1	18	0.53	0.02
Item_5 & Item_int	18	0.75	0.00
Item_int & Item_1	18	0.62	0.00
Item_int & Item_2	18	0.57	0.01
Item_int & Item_5	18	0.75	0.00

Out of the 6 x 6 =36 correlation variants, table 6 lists only the correlations statistically significant at a risk threshold $\alpha = 0.05$.

Considered globally, the values of Spearman coefficients confirm an intense and statistically significant correlation between the variables of summatory type (Av_7, Av_8), and also between each of them and variable Av_dcm, even if with lower intensity, which agrees with the observations made after Wilcoxon test application. The marks obtained for item 6, denominated as item_int (the interdisciplinary one) may be correlated with the marks of problems 1,2 and 5, as follows: the highest correlation coefficient is recorded for correlation item_int & item_5 ($\rho = 0.75$, $p<0.05$), while the lowest - for correlation item_int & item_2($\rho = 0.57$, $p<0.05$). A possible conclusion is therefore that the scheme-program, drawn as an algorithm for the identification of the unknown substances from a series of chemical equations showed the highest similarity, as to the evaluation effect produced, with the characteristics of the interdisciplinary itme, whereas the semiobjective item, meant at filling in the voids with text information, was the least similar one, by the evaluation effect produced, with the characteristics of the interdisciplinary item.

The results obtained by the pupils were quite similar with those recorded in the evaluation through semi-objective items, meant at filling in the gaps with text information, and considerably different in the evaluation by algorithms for the identification of the unknown substances from a series of chemical equations.

Another aspect had in view is the possible influence of extracurriculary activities and of the run-and-fro phenomenon upon the results of the interdisciplinary item belonging to the interdisciplinary test. Among the socio-paedagogic factors considered as influencing the results of the here analyzed test, mention should be made of the cummulative effects induced by the run-and-fro phenomenon, combined with the effects produced by the extent of involvement in the extracurricular activities in school. Figure 2 plots these effects upon the results of the interdisciplinary item.

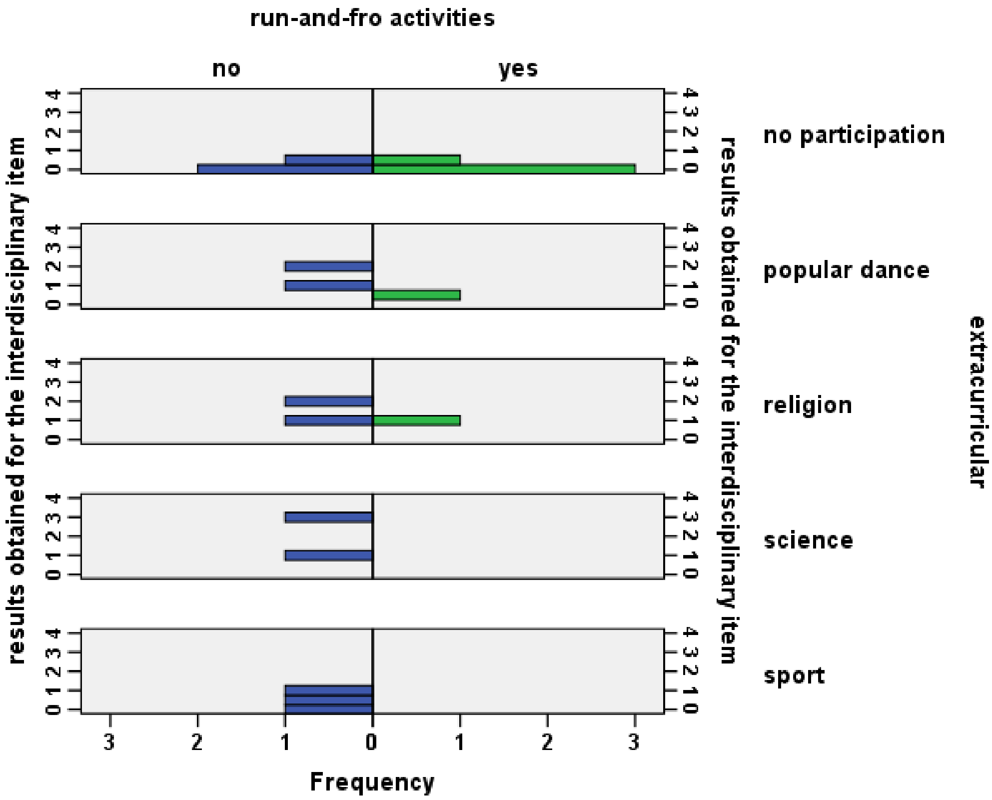

Figure 2. Influence of the extracurricular and run-and-fro activites upon the results obtained for the interdisciplinary item (item_inter), belonging to the interdisciplinary test and represented by variable Av_dcm.

Certain circumstantal, local factors, specific to the school in which the present study was developed should be also considered, namely:

The pupils who live in the same locality with their school are more numerous than the run-and-fro ones.

The extracurricular activities considered in the present study are:

-participation to scientific extracurricular activities: the environmental educational project entitled ”The world we wish to live in”;

-participation to extracurricular activities devoted to other domains: ”The little buds” art group of popular dances;

-participation to extracurricular activities of religious nature: ”Sfânta Parascheva” religion circle;

-participation to sporting extracurricular activities: rugby, various other competitions;

- the cases represented by pupils who do not participate to extracurricular activities.

As expected, the pupils having participating to extracurricular scientific activities obtained the best marks / scores of their interdisciplinary test, followed by those participating to extracurricular activities in other domains, namely the religion circle, or the art group of popular dances. The worst results were registered for pupils attending sporting activities, and no other type of extracurricular activities.

Conclusions

The present study demonstrated, on a relatively low-sized sample group, yet frequently present at gymnasium levels of the public school, the manner in which the modalities of transferring reasoning from one discipline into another – an aspect generically labelled as ”interdisciplinarity” - may provide a different learning context, to which they are still opposing. The marks / qualifications from the upper area of the docimological scale are still coming from predominantly monodisciplinary evaluation items, intensely reproductive (thus resorting mainly to cognitive registers), to the detriment of the rather applicative ones, in which the pupil re-creates the reality of facts by ”wiping out” the formal borders between disciplines. The influence of the run-and-fro phenomenon is not manifested, if considering the reduced number of the persons involved, while the influence of their participation to extracurricular activities is obviously manifested.

A possible conclusion of the present investigation is that any interdisciplinary approach lays stress on the multiple aspects of child's development: physical, intellectual, emotional, social, aesthetic, so that the interdisciplinary techniques support pupils' sustainable learning by the permanent interactions it creats among various disciplines, by correlating the specific languages of different school disciplines, thus favourizing a coherent and unitary understanding of the studied phenomena. Such coordinates represent definite advantages in the interdisciplinary organization of didactic activities. However, on the other side, interdisciplinarity does not meet all expectancies of the teacher, related to didactic organization. In this new context, the teacher is no longer the sole owner and keeper of knowledge and the exclusive agent of the one-way transfer of the infinite information he masters towards his beneficiary: the student. Therefore, especially in terms of "deletion" of the formal boundaries between disciplines - which is actually the topic of the present contribution - modern teaching should mainly focus on creating the organizational framework capable of successfully achieving the transfer of knowledge.

References

1. Stanciu, M. *Didactica postmoderna. Fundamente teoretice*; Universitatii Suceava Ed., 2003.
2. Nicolescu, B. *Transdisciplinaritatea- Manifest*; Junimea Ed., Iasi, 2007.
3. Comaniciu, C. Activitati independente utilizate in studiul compusilor hidroxilici la clasa a XI-a, in volumul „Educatia 21", nr.2/2005, apărut sub egida Catedrei de Ştiinţe ale Educaţiei, a Centrului de Cercetare şi Inovaţie în Curriculum, din cadrul Universităţii „Babes Bolyai" Cluj Napoca.
4. Salavastru, D. *Psihologia educatiei*; Polirom Ed., Colectia Colegium, Iasi, 2004.
5. Ceobanu, C., Psihologia educaţiei- o imagine actuala si de perspectiva. In *Educatia ieri-astazi-miine*, Ed. Universitatii „Al.I.Cuza", Iasi, 2004.
6. Urzica, C.B., Raportul intre profilul scolii, calitatea invatamantului si potentialul creator al elevilor. In *Educatia 21* nr.2/2005, apărut sub egida Catedrei de Ştiinţe ale Educaţiei, a Centrului de Cercetare şi Inovaţie în Curriculum, din cadrul Universităţii „Babes Bolyai" Cluj Napoca.
7. Kerekeş, A. *Conceptualizarea şi proiectarea disciplinei integrate Ştiinţe în învăţământul gimnazial*, teza de doctorat, Chişinău, 2006.
8. Jaba, E., Grama, A. *Analiză statistică cu SPSS sub Windows*, Colecţia Colegium, Editura Polirom, Iasi, 2004.
9. Cozma, D., *Suport de curs- Abordari Interdisciplinare*, Iasi, 2012.
10. Pui, A., *Suport de curs- Relaţii structură- proprietăţi în compuşi anorganici*, Iaşi, 2012.
11. Labăr, A.V., *SPSS pentru ştiinţele educaţiei*, Colectia Colegium, Editura Polirom, Iasi, 2008.
12. Howitt, D., Cramer D., *Introducere în SPSS pentru psihologie*, Colecţia Colegium, Editura Polirom, Iasi, 2006.
13. Ceausescu, D. *Utilizarea statisticii matematice în chimia analitică*", Editura Tehnica, Bucuresti, 1982.
14. Cosmovici, A., Iacob, L., *Psihologie şcolară*, Colecţia Colegium, Editura Polirom, Iasi, 2005.